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RAIL PASSENGER VEHICLE FOR REMOTE SERVICES

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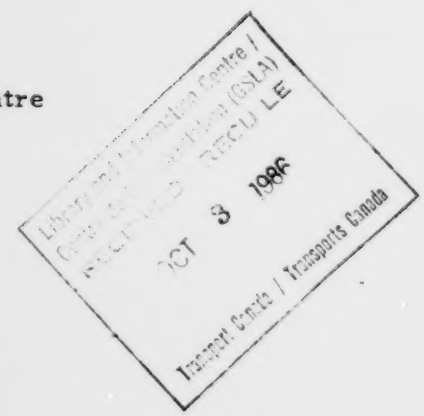

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Une préface et un sommaire en français de ce document sont inclus avant la table des matières.

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17. Abstract

The costs of providing VIA's remote rail passenger services are reviewed in relation to revenue and in the general context of VIA Rail's overall economy. A limited appraisal of existing remote train services is made with an examination of the equipment used and the various methods and costs of providing such services in cooperation with the national railways. A number of different self-propelled remote service vehicle (RSV) designs are put forward. These are proposed as replacement for the aging fleet of rail diesel cars (RDCs) now in use and as an alternative to the "mixed train" and "locomotive-hauled train" service provided by the national railways to VIA at a cost. The possible impact of these RSV designs, together with the national railways' charging policies, on the cost of providing VIA Rail's remote services is examined. The merits of various vehicle designs from the point of view of reliability, quality of service and to a limited extent cost, are also discussed.

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17. Résumé

Ce rapport présente une étude économique des services ferroviaires de VIA Rail dans les régions reculées, mettant en rapport les coûts et les recettes dans le contexte général de la situation économique de cette société. Une évaluation sommaire est faite aussi des services existants, des matériels utilisés et des modalités des ententes afférentes liant VIA aux compagnies nationales de chemin de fer, sans oublier les coûts correspondants. Le rapport propose un certain nombre de véhicules ferroviaires automoteurs susceptibles de remplacer la flotte vieillissante d'autorails diesel, ou comme solution de rechange aux trains mixtes et aux trains classiques utilisés par les compagnies nationales de chemin de fer dans le régions considérées, pour le compte de VIA Rail. Il dégage l'impact que pourraient avoir les divers véhicules envisagés sur le coût total des services considérés, compte tenu des conditions faites à VIA Rail par les compagnies ferroviaires prestataires. Enfin, il examine les divers véhicules sous le rapport de la fiabilité, de la qualité du service et, dans une certaine limite, du coût à absorber.

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FOREWORD

VIA Rail Canada Inc., Canada's national passenger rail carrier, operates a number of services on lines with low to marginal traffic densities. Some of these low-density services are secondary or feeder routes in the more populous southern regions of the country, where most communities have access to two or more modes of passenger transportation. Rail activities on these routes are amenable to rationalization, subject to political and regional constraints. However, there are in addition to these "corridor secondaries," a number of routes which serve remote areas of Canada's north. In these areas, there are few roads, air service is limited and expensive, and weather conditions restrict both road and air operations for much of the year. Many small northern communities (and individuals) depend almost entirely on rail service for access to the outside world and for supplies, mail, and other necessities. These remote services exist by virtue of social necessity, and so are much less amenable to rationalization on financial grounds. The low cost recovery target set by the Minister for VIA on some of these routes recognizes that reality, while at the same time encouraging VIA to seek more cost-effective means by which to provide these services.

Remote and regional rail passenger services are an operating and economic problem in all rail networks. Conventional rail technology (locomotive-hauled passenger coaches) is costly to procure and operate. Effective maintenance logistics require use of centralized facilities, which involves substantial non-productive mileage and loss of equipment availability. The conventional rail diesel car (RDC) is also costly and must be maintained in central shops. These large-capacity vehicles have minimum flexibility to deal with traffic variations. Crewing requirements for locomotive-hauled trains are excessive. RDC crews are slightly more economical, but still excessive for low ridership operations. Remote services in Canada are further complicated by demanding weather conditions, in particular very low temperatures, heavy snowfalls, and locally severe drifting. These conditions currently impose an additional cost penality on remote services, through the requirement to maintain and operate snowplows and support equipment on lines which would not otherwise require regular snow clearance.

Two general technology trends have emerged from attempts to address these problems. The first is based on the adaptation of a highway vehicle to rail operation with as little change as possible. The concept essentially envisages the attachment of a rail wheelset suspension directly to a highway bus structure in place of the highway suspension. The driving controls would be replaced by the required rail vehicle controls.

This concept recognizes that hi-rail vehicles have been in use for years and are an eminently practical means of locomotion on rails. The

Transport Canada project in Manitoba (Winnipeg Coach Sales and Service conversion of an 1950s vintage Flyer coach) has highlighted vividly the value of a simple, effective approach to rail technology creation.

The second technology concept, implemented by Japan, Hungary, Czechoslovakia, and the United Kingdom, involves the incorporation of a bus body, engine and transmission into a simplified, single-axle rail vehicle. By substituting mass-produced components for the traditionally high-cost, custom-made rail vehicle subsystems, significant cost reductions have been achieved. These vehicles are typically half the cost of an equivalent conventional rail vehicle. Their appearance is more typical of a classic railway vehicle, except for the lack of conventional bogies and the unusual aspects of the doors and windows.

The principal exponents of this approach are BREL-Leyland in the U.K., and Ganz-Mavag/Ikarus of Hungary. Both have vehicles in test operation and revenue service in various locations around the world.

However, neither of these development initiatives fully addresses the issue of reliable winter operations independent of separate snowplows and support vehicles. This project attempts to overcome this deficiency through development of a range of conceptual designs for a purpose-built remote services vehicle (RSV).

As presently envisioned, such a vehicle would be self-propelled, suitable for bi-directional operation, require a single operator, and carry a minimum of twenty passengers and baggage. It would be equipped for "ship-at-sea" operation (small kitchen, toilet, ample on-board heating, etc.), and be capable of handling most snowplowing tasks without assistance. Operational safety and reliability would be priorities.

The ultimate objective of this initiative is to develop a technologically superior, economically attractive alternative to existing equipment for use in provision of remote area passenger services. Achievement of this ultimate objective encompasses distinct sub-objectives:

- development of one or more conceptual designs
- comprehensive benefit/cost evaluation to identify the most attractive alternatives
- preparation of detailed working drawings
- construction and testing of a prototype.

The work reported here covers the first of these sub-objectives. This project explored possible design concepts for the remote services vehicle, including a first-order examination of benefits and costs, and the preparation of suitably-scaled preliminary drawings for selected designs.

PRÉFACE

VIA Rail Canada, Inc., société d'État chargée du service ferroviaire voyageurs, assure un certain nombre de dessertes où la demande va de quasi inexistante à faible et dont quelques-unes sont de type secondaire, c'est-à-dire de rabattement sur les lignes desservant les régions plus au sud, caractérisées par la concurrence entre deux ou plusieurs modes de transport voyageurs. Il y aurait intérêt à rationaliser ces dessertes dites secondaires, sous réserve des contraintes politico-régionales. Cependant, il existe également des dessertes de ce type dans les régions reculées du Grand nord canadien, où il y a peu de routes, des services aériens restreints et très coûteux et un climat hostile au transport routier et aérien pendant la plus grande partie de l'année. Or, dans ces régions reculées se trouvent un grand nombre de villages dont la survie dépend exclusivement du rail qui leur apporte les fournitures et les denrées nécessaires, en plus d'être leur seul moyen de communication avec l'extérieur. Ces services ont un caractère essentiellement social et ne peuvent donc pas être soumis à une rationalisation fondée sur des impératifs purement financiers. Le Ministre, reconnaissant cet état de choses, a d'ailleurs fixé à ces dessertes un taux de récupération des coûts faible, ce qui ne doit pas empêcher VIA de rechercher des moyens de rentabilisation de ces services payants.

Les services voyageurs offerts dans les régions plus ou moins reculées sont vues par toutes les sociétés de chemins de fer comme une charge économique et technique. D'une part, parce qu'un train classique coûte cher à mettre en oeuvre et, d'autre part, parce que les impératifs d'efficacité de l'entretien exigent des installations centralisées et entraînent, par le fait même, une importante circulation non payante et un taux élevé d'indisponibilité du matériel roulant. Quant aux autorails diesel, ils souffrent des mêmes inconvénients : cherté et entretien centralisé. Qui plus est, ces deux modes de transport grande capacité répondent mal aux variations de trafic. Enfin, le premier commande un personnel de bord trop nombreux tandis que l'effectif réglementaire du second dépasse les besoins dés que les niveaux de trafic baissent. Ces dessertes sont rendues encore plus difficiles par des conditions climatiques rigoureuses, caractérisées par des températures trés basses, d'importantes chutes de neige et de fortes poudreries, qui alourdissent encore plus le coût de ces services du fait de l'utilisation et de l'entretien d'un important matériel de déneigement et des équipments connexes.

La recherche d'une solution acceptable a dégagé deux filières distinctes. La première consiste à adapter un véhicule routier à la circulation sur rails, en n'y apportant que très peu de changement. Pour cela, on se contente de remplacer la suspension routière par une suspension ferroviaire du type essieu monté, et les commandes par d'autres plus appropriées au service ferroviaire.

Loin d'être novatrice, puisqu'il existe déjà des engins rail-route, cette filière a néanmoins débouché sur des techniques de transport éminemment pratiques, comme, par exemple, ce railbus réalisé par la Winnipeg Coach Sales and Service au Manitoba avec le concours financier de Transports Canada et qui fait appel à un autobus de type Flyer des années 1950 converti en véhicule ferroviaire. D'ailleurs, cette application a montré à quel point une approche simple peut être aussi efficace dans le domaine du ferroviaire.

L'autre filière, dont on trouve des exemples au Japon et en Europe (Hongrie, Tchécoslovaquie, Royaume-Uni), consiste à monter une carrosserie d'autocar équipée d'un moteur et d'une transmission sur un châssis ferroviaire à deux essieux. En remplaçant les équipements coûteux des chemins de fer classiques par d'autres de production série, le coût de réalisation est sensiblement réduit, de l'ordre de 50 p. 100 dans les cas types. Quant à l'apparence, elle ne change guère par rapport au véhicule ferroviaire classique, hormis l'absence des bogies et la forme des portières et des fenêtres.

Les principales réalisations de cette filière en Europe sont dues à la compagnie anglaise BREL-Leyland et à la Ganz-Mavag/Ikarus de Hongrie, qui, toutes deux, ont plusieurs exemplaires de leur matériel en service expérimental payant un peu partout dans le monde.

Toutefois, aucune de ces deux filières n'a attaqué de front le probléme de la viabilité hivernale, se rabattant sur l'utilisation d'engins chasse-neige et d'autres matériels de déneigement. Or, notre projet vise justement à trouver une solution à ce problème par l'etude d'un certain nombre de concepts ayant pour objet la réalisation d'un matériel pour services ferroviaires dans les régions reculées.

Le matériel envisagé pourrait être formé d'un véhicule automoteur réversible, capable de transporter au moins 20 voyageurs avec leurs bagages et dont le personnel de bord serait réduit au seul conducteur.

En plus d'être équipé pour une grande autonomie : cuisinette, toilettes, installations de chauffage largement dimensionnées, etc., il pourrait assurer la plupart des travaux de déneigement sans aide extérieure. Enfin, il serait capable d'un fonctionnement sûr et fiable dans toutes les conditions climatiques prévisibles.

La recherche a donc pour objectif général la réalisation d'un matériel de haute technologie et économique pour remplacer celui qui assure la desserte des régions reculées; ses sous-objectifs sont les suivants:

- dégager un ou plusieurs concepts envisageables,
- trouver les plus intéressants par des études de rapport avantages-coût,

. tirer des dessins d'exécution, et

. procéder à la réalisation et, à l'essai du prototype.

Le présent rapport rend compte des travaux effectués à l'égard du premier de ces sous-objectifs : examen des concepts proposés, y compris l'étude préliminaire du rapport avantages-coûts et la réalisation de dessins préliminaires à l'échelle appropriée metérialisant les concepts retenus.

SUMMARY

The provision of rail passenger services to remote communities in Canada poses complex problems from an economic point of view and from the standpoint of practical implementation.

Remote communities are dispersed along rail routes dedicated principally to the transportation of freight. Ridership between many of the communities varies considerably along continuous routes. On other routes ridership is small but regular, while still others have large but intermittent ridership.

To provide passenger service in these communities, VIA has recourse to various means, including "mixed trains," locomotive-hauled trains, and self-propelled rail diesel cars (RDCs).

The proposed remote services vehicle (RSV) designs could provide the service presently given by the RDC. They would have a lower capacity but some would have the ability to operate in snow cover which would immobilize a conventional RDC.

It has not been possible to assess or include the value of snow removal operations, but consideration of the variable railway operating costs indicates that for the RSV these could possibly be lower than those for the RDC, but only by $0.50 to $1.25 per mile. The reason for this would be mainly because for any new equipment, maintenance costs would be less, and also because of the possibility of reducing the crew.

Extension of RSV service to some routes presently served by "mixed trains" could result in some saving for VIA, but only if CN is successful in implementing its proposal to charge VIA for crew, locomotive and other train-variable costs. If the present pricing structure is maintained, there would be an almost equal increase in costs to VIA resulting from this action.

In the case of conventional locomotive-hauled remote service trains, where ridership is very low, substitution of RSV service on some sections of the route may result in some saving, though it is felt that this would be marginal.

From the point of view of design and quality of service, the proposed RSV designs offer various degrees of elaboration. The choice of any of these will depend largely on the location and climatic conditions prevailing along the various routes. Since the specifications called for the RSV to be able to handle a certain amount of snow cover, special snow clearing equipment was added.

It was found that the ability to handle even the moderate amount of snow cover specified required significant installed power capability in addition to that required for mere propulsion.

The designs put forward have various snow handling capabilities, ranging from deep drifts to clear track.

It would appear that hydrostatic transmission may be an attractive alternative to traditional mechanical or electric transmissions due to the possibility of using "off the shelf" components, lower cost and favourable transmission characteristics. At the same time, it is felt that with proper instruction and some simple basic training, maintenance of hydrostatic systems could be simpler and less costly than that for other systems.

The study indicates that cost savings in operation of remote services routes may be largely dependent on the charging policy of Canadian National Railways for providing VIA Rail with mixed train service. If this policy is maintained, then there is nothing to be gained by replacing the present mixed trains with other vehicles. On the other hand, if CN's proposed new charging system is implemented, some saving is possible by replacing mixed trains with VIA's own vehicles.

In the latter case there would only be a slight cost advantage in favour of introducing an RSV as opposed to the conventional RDC.

In other types of remote service, the case for the RSV on the basis of cost is even weaker. If it is proposed to replace the aging fleet of RDCs currently in service, a case may be made for the RSV on the basis of first cost, quality of service, reliability, ability to negotiate snow-covered track, and ease of maintenance. In this case, it is recommended that the various proposed designs be engineered to a more advanced degree, permitting a more accurate and complete costing of the various systems to be made.

In the macro-economic prospect, the use of RSVs for passenger transportation between remote communities will have very little impact on the cost of the service.

SOMMAIRE

La desserte ferroviaire des régions reculées du Canada pose des problèmes aussi complexes que nombreux, tant du point de vue économique que technique.

Il y a aussi le fait que les points à desservir sont éparpillés tout le long d'itinéraires ferroviaires à vocation principalement marchande et que le traffic entre eux est très fluctuant: il peut être faible, mais régulier, ou bien important, mais périodique.

Pour assurer la desserte de ces points, VIA met en oeuvre plusieurs moyens, dont les trains mixtes, les trains classiques et les autorails diesel.

Le concept de la desserte ferroviaire pour régions reculées mis de l'avant vise à assurer les services actuels confiés aux autorails diesel, tout en mettant en oeuvre un matériel de capacité plus petite mais capable de circuler sur des parcours enneigés qu'un autorail diesel classique ne pourrait emprunter.

Il n'a pas été possible de prendre en compte ni même d'évaluer le coût du déneigement, mais les chiffres relatifs aux coûts d'exploitation des sociétés de chemins de fer montrent qu'en ce qui concerne un matériel de desserte pour régions reculées, le déneigement ne coûterait que de 0,50 à 1,25 $ de moins par mille, par rapport à l'autorail classique. Cette économie serait surtout attribuable au fait qu'avec tout équipment neuf le coût de l'entretien est moindre, mais aussi parce qu'il n'y aurait qu'un seul agent à bord.

Le replacement des trains mixtes desservant les régions reculées par le matériel envisagé pourrait faire réaliser à VIA certaines économies, mais seulement si le CN réussit à faire accepter la nouvelle politique de facturation, celle qui consiste à facturer VIA pour les prestations qu'il lui fournit : agents de bord, matériel de traction et autres coûts de traction variables. Si la politique de facturation actuelle devait être maintenue, les économies réalisables seraient annulées par une augmentation presque égale dans les coûts facturés à VIA.

Dans le cas du train classique utilisé pour la desserte des régions reculées où le trafic est très faible, l'utilisation du matériel envisagé pourrait apporter des gains sur certaines lignes, mais dans des limites très réduites.

Du point de vue caractéristiques techniques et qualité du service, les concepts proposés peuvent être plus ou moins élaborés. Le choix d'une configuration donnée dépendra en fin de compte de l'endroit où le service sera fourni et des conditions climatiques. Étant donné que le cahier des charges stipule l'enlèvement de la neige à concurrence d'une hauteur donnée, un matériel de déneigement adéquat a donc été prévu.

Or, l'exigence d'enlever même une petite couverture de neige entraîne une augmentation sensible dans la puissance installée, par rapport à celle requise pour la simple traction.

C'est pourquoi il a été proposé des concepts dont la capacité de déneigement augmente progressivement jusqu'à atteindre celle de dégager les très épaisses couvertures de neige.

Il est apparu qu'une transmission hydrostatique pourrait remplacer avantageusement la transmission classique, mécanique ou électrique, et ce pour des raisons de disponibilité des accessoires, de moindre coût et de meilleures caractéristiques techniques. Qui plus est, il est possible que l'entretien d'une transmission hydrostatique soit plus aisé et moins coûteux, sous réserve d'une bonne formation de base du personnel responsable, complétée d'un bon apprentissage.

L'étude a montré que les économies réalisables dépendent avant tout de la politique de facturation pour les prestations fournies par les Chemins de fer nationaux à VIA Rail en services de trains mixtes. Si la présente politique devait être maintenue, il n'y aurait aucun avantage à remplacer ceux-ci par un autre type de train. Si, par contre, la nouvelle politique proposée par le CN était mise en oeuvre, alors il pourrait être intéressant de remplacer les trains mixtes par un matériel appartenant à VIA Rail.

Par rapport à l'autorail diesel classique, ce remplacement apporterait des gains, bien que légers.

Quant aux autres types de desserte éloignée, les avantages économiques du matériel envisagé sont encore plus faibles. Si l'on envisage de remplacer le parc vieillissant d'autorails diesel par un tel matériel, celui-ci pourrait l'emporter d'après des critères comme le coût de premier établissement, la qualité du service, la fiabilité, le déneigement de la voie et l'entretien plus facile. Dans ce cas, il est recommandé de pousser la recherche sur les concepts envisagés au point d'en permettre une étude des coûts qui soit plus juste et plus complète.

Sur le plan macro-économique, l'emploi du matériel envisagé pour le transport ferroviaire de personnes à l'intérieur des régions reculées n'aura qu'un impact très limité sur le coût de service offert.

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1. INTRODUCTION

Remote and regional rail passenger services on lines with low traffic densities are an operating and economic problem on all rail networks. Conventional rail technology (locomotive-hauled passenger coaches) is costly to procure and operate. Effective maintenance logistics require use of centralized facilities, which involves substantial non-productive mileage and loss of equipment availability. The conventional rail diesel car (RDC) is also costly and must be maintained in central shops. These large-capacity vehicles have minimal flexibility to deal with traffic variations. Crewing requirements for locomotive-hauled trains are excessive. RDC crews are slightly more economical, but still excessive for low ridership operations.

Remote services in Canada are also characterized by several unique features. Extremes of terrain and climate contribute to difficult operating conditions and limited and uneven ridership on these lines.

Low ridership and the political requirement for equitable fares keeps gross revenues low, while the length (average approximately 320 km) and location of the routes create significant operating diseconomies. These services result in a share of VIA's operating loss. For 1984, the various remote service routes incurred costs of $66.2 million, while recovering revenues of only $6.2 million. The resulting loss of $60 million was 12.5 per cent of VIA's total loss for the year, while the remote routes contributed only 7.5 per cent of VIA's total passenger miles, and 7.9 per cent of total train-miles. The loss per passenger-mile for the remote services was $1.10, just over 3.5 times the average loss for VIA operations.

Although improved ridership would help to reduce this level of deficit, the opportunities for revenue enhancement are very limited. Short of service abandonment, which has not been politically acceptable to date, cost reduction is the only method available to reduce the direct financial losses attributed to remote services.

Section 2 identifies existing (and some recently discontinued) remote services routes, examines the typical cost structure for remote services, identifies the cost elements which are sensitive to vehicle performance and the functional requirements which define the required

performance standards, and discusses the regulatory and legal requirements which underly existing operations.

Section 3 presents a range of design concepts which address the functional requirements, including an overrun of railbus technology options.

Section 4 compares the design-specific cost elements for each of the conceptual designs.

Section 5 presents conclusions and recommendations.

2. CANADIAN REMOTE SERVICES

The characteristics of the train runs that make up Canada's "remote services" are relatively heterogeneous. The main unifying factor is that these services are operated over routes which are not served by alternate ground services, and that ridership levels are low to very low. In some instances, remote services and "normal" intercity services are provided on different segments of the same train run.

Current and recently abandoned "remote" services are summarized in Table 1. This table includes some non-VIA services, such as the Ontario Northland's Cochrane-Moosonee route.

The passengers-per-train-mile ridership values presented in Table 1 have limited use in determining suitable vehicle and train sizes for remote service applications. This statistic averages the ridership over all trains operated during the year -- masking any weekend or seasonal peaks, and over the whole route -- masking the differences in passenger demand over various route segments.

More detailed (but out-of-date) passenger statistics provided by VIA and the capacity offered by the current consists indicates that a much higher capacity than that required to meet the ridership shown in Table 1 is required to serve peak periods and peak route segments.

There are various types of remote services. The **mixed trains** operate over secondary railway lines not served by other passenger trains. On these trains, one (or two) combination baggage car/coaches are operated as part of a freight train. Average ridership is very low and peak ridership is typically in the range of 25 to 35 persons.

Many of the other remote services are separate passenger trains operated over CN main lines or major secondary lines, including some overnight runs. These trains vary in size from four to six cars. Ridership is typically higher than on mixed trains.

The operational requirements -- as opposed to technical requirements -- for remote service trains are reasonably simple, and can be briefly summarized.

TABLE 1

CHARACTERISTICS OF CURRENT AND
RECENTLY ABANDONED REMOTE SERVICE ROUTES

Train No.	Route	Train	Frequency	Size** (cars)	Average Ridership†	Distance (miles)	Trip Time
203/204	Bishops Falls-Corner Brook	Mixed	Daily			138	5:10
205/206	Clarenville-Bonavista	Mixed	1/week			89	4:20
207/208	St.John's-Argentia	Mixed	3/week			84	3:55
231/232	St.John's-Carbonear	Mixed	3/week			80	4:00
272/273	Hearst-Nakina	Mixed	3/week	1	1.6	144	5:30
277/278	Sioux Lookout-Thunder Bay	Mixed	2/week	1	1.3	202	7:02
290/291	The Pas-Lynn Lake	Mixed	3/week	2	12.0	242	10:15
294/295	Wabowden-Churchill	Mixed	1/week	1	1.6	436	
7/8	Capreol-Winnipeg	Passenger	3/week	2-4	22.4	931	24:15††
148/149	Farlane-Winnipeg	Passenger	F/S*	7-8	70.7	138	3:40
9/10	Edmonton-Prince Rupert	Passenger	3/week	4-6	39.0	957	25:00††
92/93	Winnipeg-Churchill	Passenger	3/week	5-6	31.0	1,055	37:15††
132/ 133-128	Montreal-Chicoutimi	Passenger	3/week	4	24.8	318	9:25
132-142/ 141-135	Montreal-Senneterre	Passenger	3/week	4-5		437	14:00††
137-143/ 144-136	Senneterre-Cochrane	Passenger	3/week	1	38.7	184	5:35
185/186	Sudbury-White River	RDC	3/week*	1	6.7	301	8:20
128/129	Toronto-Kapuskasing	Passenger	Daily			551	14:10††
ONR	Cochrane-Moosonee	Passenger	6/week			186	4:20
ONR	Cochrane-Moosonee		2/week			186	5:35
ACR	Sault Ste.Marie-Hearst		6/week			296	8:45
CN	Edmonton-Waterways	Mixed		2			
QNSL	Sept Isles and north						
WP&Y	White Horse-White Pass	Passenger					

* Summer only
** 1984 VIA Consist Assignment book
† Average ridership per train-mile supplied by VIA.
†† Overnight trip

(a) Sufficient baggage capacity must be provided to handle significant amounts of oversized and bulky "luggage" such as canoes and oil drums. Technically, these items are freight, but the spirit and intent of the CTC's rulings on remote service applications require that this capability be provided.

(b) Sleeping accommodation and some form of food service should be provided on overnight trains. Again, this is part of the spirit and intent of the CTC rulings. Typically, the sleeping car utilization on such trains is very low, compared to other overnight trains. The CTC rulings can be interpreted as not requiring a separate sleeping car per se, if some sleeping accommodation is provided.

(c) There must be sufficient capacity to meet passenger demand, but passenger accommodation can be quite basic, depending on the individual train runs. A full range of amenities such as is offered on Corridor or Transcontinental trains is not necessary for remote services.

(d) Reliability must be reasonably high. Again, due to the nature of many of the remote services, the spirit and intent of the CTC rulings requires that considerable effort be expended in meeting the schedule (especially during winter) and protecting against on-the-road failures.

(e) The vehicle should be able to operate in light to medium snow without a separate snowplow and have sufficient weight and traction to run through snow ridges at grade crossings where highway departments have plowed snow.

2.1 Cost Structure for Remote Services[1]

The costs of various remote services fall into the following general categories:

(a) railway (CN, CP or VIA) charges for operation and maintenance of the trains themselves and associated overheads and ancillary charges; these can be considered "direct"[2]

(b) railway charges for the use of stations and other fixed facilities (including some component of track) and other "fixed" charges; these are allocated by VIA to various services

(c) VIA expenses for administration, sales and other overheads; some of these are "direct," but most are VIA's allocation of total corporate expenditures to various services.

The choice of equipment for remote services has its major impact on the first group of costs -- fuel, crew, equipment maintenance, and the traffic-variable component of roadway maintenance. Equipment selection should have little impact on the station and other "fixed" railway charges. The impact on allocation of VIA expenditures is less clear.

There are currently three broad equipment types for remote services -- fixed trains, locomotive-hauled passenger trains, and self-propelled (RDC) cars.

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1 The cost data in this section is drawn from VIA Rail Canada's Short Train Study and from information provided by VIA. For the most part, average values have been used. Various subtle differences in costs have not been incorporated. They have been examined, however, and do not affect the conclusions reported here. The cost discussion here treats CN charges to VIA as VIA's costs. The impact of technolgical change is considered only within the context of the present costing regulations. This study does not consider changes to the regulations.

2 These direct costs include a direct allocation for the use of infrastructure through a train-mile linehaul charge and a gross ton-mile roadway maintenance and capital charge.

2.1.1 Mixed Trains

For mixed trains, the typical pricing structure that the CTC has authorized CN to use in the past has been to charge only for the passenger car(s) in the train, limited to the car's fuel, its maintenance and the car's share of roadway maintenance components. The pricing structure has not included an allocation for the train crew, the costs associated with the locomotive, or other charges for roadway use, assessed on a train-mile basis. (The rationale for this is that mixed trains are way freights which will move anyway, with the passenger car being treated as incremental. CN has applied to the CTC to revise the definition and costing treatment of some mixed trains so that freight, if any, is considered the incremental traffic.)

For a typical mixed train (such as VIA 277/278 operated twice a week with a combination baggage/coach over the 202 miles between Thunder Bay and Sioux Lookout), the variable railway charge would be on the order of $2.20 to $2.80 per car-mile, including railway overheads.[3] Approximately 5 per cent of this is roadway maintenance (and capital) and 30 per cent is fuel. The balance of the costs are for car maintenance and servicing.[4]

For this typical mixed train, these variable costs (in the 1981 recapitulation) represented approximately 60 per cent of the total railway charges. Another 30 per cent of the charges were for yard switching and 8 per cent for station rental/operations, while the rest were various fixed and overhead charges.

On this basis, the overall railway charge for mixed train service (in $1984) is in the range of $3.65 to $4.25[4] per car-mile.

If VIA were assessed the total crew and other train-variable costs for mixed trains, the variable costs would increase by about $11 per mile.

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3 This figure will vary slightly with frequency of service and distance since some car maintenance and cleaning costs are developed on a car-day basis and then back-allocated on a mileage basis.

4 For one locomotive. These are cases where two locomotives -- at a higher cost -- have been used for reliability.

Of this, approximately 40 per cent is for crew, 30 per cent is for the locomotive[5] and 30 per cent is for roadway use.

2.1.2 Locomotive-Hauled Train

For a standard locomotive-hauled train, the costs developed can be applied. Railway costs would be approximately $11 per train-mile plus $2.20 to $2.80[6] per car-mile. In addition, station, switching and other charges would apply.

2.1.3 Self-Propelled Equipment

The self-propelled equipment costs are essentially those of a train without a locomotive. The maintenance and servicing costs for a vehicle (RDC) are higher than that for a single car. Fuel costs are somewhat lower. A single RDC can operate with a two-man crew as opposed to a three- or four-man crew for a conventional train. For the example Thunder Bay-Sioux Lookout service, RDC costs would be approximately $9.50 per mile[7] (plus station and other charges). This breaks down to approximately one-third for vehicle maintenance and servicing, one-third for roadway charges, and one-quarter for crew. The balance of the costs are mainly switching and overhead charges.

2.2 Projections for a Remote Services Vehicle

The design of the remote services vehicle discussed in this report has not progressed to a stage where accurate costing can be undertaken. However, it can be expected that the RSV would have a cost profile similar to that of an RDC.

Variations in weight will result in a change in roadway maintenance costs. These, however, are a minor component of the overall RDC

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5 For one locomotive. These are cases where two locomotives -- at a higher cost -- have been used for reliability.

6 Different costs apply to other equipment types, the combination baggage/coach being the least expensive.

7 A second RDC would add approximately $5 to the costs while a third RDC would add approximately $4. The added cost is caused by adding a third crew member.

costs. Fuel efficiency can also be expected. Again, the total impact will be minor, with even a substantial increase in fuel efficiency resulting in less than a 1 per cent decrease in the $9.50 per car-mile cost of the RDC. There is potential for savings in vehicle maintenance and servicing. This would be due both to the newness of the equipment (which would be applicable on almost any new equipment) and to design considerations. A savings of $1 per car-mile would be the maximum from this area.

Crew savings over the present RDC are possible, but unlikely in the short term. A single RDC operates with a two-man crew under current agreements. Physically, it may be possible to use only one man, and some of the RSV designs being considered would improve the logistics of one-man operation. Either requires the driver to leave his position to entrain/detrain passengers and handle baggage, etc. In the rail mode, such a change would require considerable negotiations with the Brotherhoods, UTU and the CTC. (In this regard, it is significant to note that the railways generally require two occupants in hi-railers and similar equipment on their track.) If the reduced crew is possible, the savings would be equally achievable by either the RDC or the RSV.

In general, the roadway charges are assessed on a train-mile basis and would not be altered by the selection of equipment. VIA may be able to negotiate savings in this area, but such savings would be applicable to all trains. Since the roadway charges include an allowance for snow clearing, an RSV which can plow its own snow would have some advantage. When operated on high-density main lines, this may not be an issue. We have been unable to isolate the value of snow clearing.

In summary, the variable railway operating costs for a potential RSV should be lower than that of the RDC, but only on the order of $0.50 to $1.25 per mile.

2.3 Capital Charges

The capital charges (depreciation) in the VIA Remote Services are based on an arbitrary allocation of total capital charges by train-mile. VIA is moving towards a service-/equipment-specific form of costing which will change the reported deficit.

The current equipment has an average book value (mid-1983) of $44,000 for coaches, $44,000 for locomotives (plus $460,000 if fully upgraded) and $105,000 to $125,000 for an RDC.

At a 5 per cent depreciation rate (6 per cent for locomotives), $0.05 per mile in depreciation must be added to the coach costs, $0.06 per mile (plus $0.66 if fully upgraded) to locomotive costs, and $0.14 per mile to RDC costs for the typical Thunder Bay-Sioux Lookout run.

On the same basis, a new RSV which costs $500,000 would require a depreciation charge of $0.60 per mile. (A full capital charge, which ignores the fact that new equipment is funded differently than operating deficits, would be on the order of $0.85 per mile.)

With proper maintenance, any such new RSV could be expected to last for 20 to 25 years without major upgrading. This would not be the case with the current equipment. Maintenance costs and reliability problems can be expected to increase unless the equipment is replaced or upgraded. The capitalized value of such upgrading could be as much as $0.20-0.25 per mile.

2.4 The Market Potential for the RSV

Given only the basic train consists and average ridership over the year, it is not possible to do a full assessment of the market potential of the RSV. Estimation of some portions of the market are offered. A better breakdown of passenger demand patterns, especially by route segment and season or day of the week, will be necessary before definitive conclusions can be reached.

The best candidates for the RSV are the day trips which are currently listed as mixed trains, but only if CN is successful in implementing its proposed system of charging VIA for crew, locomotive and other train-variable costs. Use of the RSV could save VIA on the order of $4.50 to $5.00 per mile for a single-car train (including depreciation). Savings would be somewhat less for a two-car train and/or for RSVs with a capital cost higher than $500,000. For the example Thunder Bay-Sioux Lookout service, the annual savings would be on the order of $200,000 on a variable operating cost base of $575,000.

In the case of these mixed trains, the demand level is generally low enough that one RSV would provide sufficient passenger and baggage-carrying capacity. There would be some runs/days in which a second RSV would be required. Despite the higher cost per mile for vehicle maintenance and servicing, the overall operating cost of a two-vehicle RSV train would be less than the cost of providing the same capacity with conventional equipment. Based upon the current cost structure, a three-vehicle RSV consist appears to be the upper limit on cost effectiveness. Above that, conventional equipment would have a lower cost.

If VIA is successful in maintaining the present pricing structure for mixed trains, use of the RSV would increase the costs to VIA by as much as $5.50 to $6.00 per mile. For the Thunder Bay-Sioux Lookout service, these extra costs would amount to $250,000 annually.

Use of the RSV should result in a superior quality of service being offered. In theory, such an improvement should lead to increased revenues either as increased ridership and load factors or increased fares, or some combination of both. At a present fare of $0.124 per mile on the Thunder Bay-Sioux Lookout example, a substantial increase would be needed to balance the extra cost. At the current fares, the incremental revenue to cover the added costs of $250,000 (for an RSV service versus a mixed train service) would require that ridership more than double. In practice, it appears that the use of the RSV would induce little if any additional demand and would not justify significant fare increase.

It is clear that not all of the remote services summarized in Table 1 are reasonable candidates for the RSV. On some, the level of demand is large enough that multiple RSVs would need to be operated. With a 20-40 seat capacity and with a separate power plant in each vehicle, costs would be high. In such cases, conventional locomotive-hauled trains with higher-capacity cars would be more cost-effective. The Winnipeg-Farelane service is a typical example. Other services such as Edmonton-Prince Rupert and Winnipeg-Churchill would also not be candidates for the RSV, since these are relatively long trips and overnight facilities are required.

There are some conventional locomotive-hauled remote service trains where the RSV may offer cost savings. For example, the extension to Cochrane of the Montreal-Sennetere service has very low ridership and only a single car is used. RSV operating costs would be lower. Since the current equipment is taken from the Montreal train, there would, however, be a decrease in overall utilization which would reduce the net operating cost savings.

In overall practice, the RSV could fit into VIA's fleet and service planning in the same way that RDCs are now used, albeit with a somewhat smaller capacity.

Passenger demand, snow removal ability and the desire for standardization would dictate which of the candidate RSVs would be most appropriate. All are similar, and at this stage there is not sufficient design information to quantify detailed cost differences. A lighter-weight vehicle would cost somewhat less to operate; however, the weight-related costs (roadway maintenance and, to a lesser extent, fuel) comprise only 6 to 8 per cent of total costs for current operation of an RDC. The ability to operate in snow is a definite asset, although from the cost information available from VIA, it has not been possible to put a value on snow removal. Vehicles with two independent power plants should offer an advantage in terms of reliability since a power plant failure would not strand the vehicle. For a small fleet, there could be advantages for VIA to standardize on a single vehicle, using somewhat more expensive and more powerful/higher capacity equipment on some routes than is needed. Better interchangeability, reduced unit acquisition costs and fewer maintenance procedures are the principal benefits of fleet standardization.

3. DESIGN PROPOSALS

This section describes various design proposals in some detail.

When considering the requirement for dealing with even the moderate snow cover specified, it soon became apparent that the power required for this purpose was much greater than that required for propulsion of the vehicle itself. Since the choice of power units and transmissions and their design has a very significant effect on overall vehicle design, it was concluded that the ability to deal with the snow cover was a consideration of major importance in the design. Consequently, the problem of snow clearing has been studied in sufficient depth to make it possible to come up with a feasible design. The theoretical analysis is given in the appendices.

3.1 Modular Concept

The basic version of the modular concept of the remote services vehicle was designed to meet the functional performance requirements with the exception of the requirement for a separate trailer to transport baggage. Baggage space is actually provided in the vehicle together with accommodation for passengers, etc. It was felt that in the event of transportation of hazardous materials such as gasoline, propane, etc., where separation from the passenger area would be required for safety, a separate trailer could be attached. Such a trailer would be little more than a small freight car with a low freight zone floor to facilitate loading from the track-side platform.

The basic modular version of the design is shown in Drawing No. 7 (Appendix G). It consists of a two-truck, four-axle, self-propelled rail car with accommodation for twenty passengers and a crew of two. On-board facilities include a unisex washroom fitted with chemical toilet, wash basin and holding tank, primary heating system with secondary back-up, and external snowplowing surfaces for clearing snow up to 7.6 cm ATR from the track. The latter take the form of retractable snowplowing surfaces (item 14), complete with flangers. These surfaces are capable of removing 7.6 cm ATR snow cover while flanging to a depth of 5 cm below the top of the rail. They, therefore, remove a layer of snow, while plowing, up to a maximum of 12.6 cm thick.

Detailed discussion of the design commences with the design of the power units and transmission. Subsequently, the various other features of the vehicle are discussed.

3.1.1 Power Units and Main Transmission

The power unit is required to propel the vehicle at its maximum specified speed on clear track and also to negotiate snow-covered track to a depth of 7.6 cm ATR (3 inches, see Appendix J, Functional Requirements) at reduced speed. For the design it has been assumed that the specific weight of snow being plowed is typically 240 kg/m^3.

While it is known that the density of snow is variable between wide limits, it was assumed that in remote locations the snow may lie for some time before plowing. Under these circumstances, the density tends to increase with time. It has been recommended that the value of 240 kg/m^3 be used for the design of buildings (National Building Code of Canada, 1980a, see Ref. 3). It is considered that this value would be appropriate for use in this context.

The plow blade is 3 m wide and, therefore, the area of the channel being plowed is 3 x 0.126 = 0.387 m^2. In the plow geometry shown, the maximum angle, α (see Figure 1), is 135° while the angle of attack, β, is 51°. The mass of the vehicle is assumed to be 54,400 kg, and that of a trailer 18,100 kg. Using the equations in Appendices C and D, Table 2 was compiled. It gives required power to propel the vehicle and clear the specified depth of snow while moving on level track. A graph of the relationship is shown in Figure 4 (Appendix H). This shows that in order to travel on clear track at 100 km/h while towing a trailer, the tractive power required is 260 kW. While clearing snow, it is noted that in order to travel at the reduced speed of 55 km/h the total requirement is approximately 400 kW.

If the trailer is removed, then the power required to travel at 100 km/h on clear, level track is 215 kW.

With these figures in mind, it was decided to power the basic vehicle with two Cummins NTA-855-L3 diesel engines delivering 242 kW each at 1,800 rpm.

TABLE 2

POWER/SPEED RELATIONSHIP FOR BASIC VERSION

Meters per second	Km per hour	Power to Propel Vehicle (kW)	Power Required to Plow Snow (kW)	Total Power (kW)
30.5	109.7	331	2,681	3,012
27.5	98.8	250	1,954	2,204
24.4	87.7	184	1,372	1,556
21.3	76.8	131	919	1,050
18.3	65.8	89	579	668
15.2	54.7	58	335	393
12.2	43.9	36	171	207

The main propulsion transmission is a hydrostatic system in which each engine drives a Hydromatic A4V-250 variable-capacity hydrostatic pump fitted with a pressure compensator. Each pump works in closed circuit with two fixed-capacity Hydromatic A2F-355 motors connected hydraulically in parallel, one driving each axle of a truck via an axle-mounted gearbox. Thus, all four axles of the remote services vehicle would be fitted with gearboxes and hydrostatic motors.

When operating on clear track, both engines would operate but two of the hydrostatic motors would be isolated from the hydraulic system and declutched, allowing the associated axles to free wheel. Under conditions of moderate snow cover, all the motors would be brought into service so that all axles would be driven.

The diesel engines would run at constant speed, the speed of the vehicle being controlled by adjusting the setting of the constant pressure controls on the variable-capacity pumps. This type of control would automatically ensure that each engine would take its due share of the load and it would not be necessary to synchronize the engine speeds. Thus, the engines could be equipped with isochronous governors with no elaborate speed drop characteristics. Maximum hydraulic operating pressure would be in the range of 20.7 to 27.6 M.Pa.

In the arrangement shown, the engines are placed with their axes parallel to the direction of travel. The radiators and blower fans for the cooling system are located in the roof of the vehicle. The cooling system would be thermostatically controlled and include a heat exchanger for heating the passenger area.

Each engine is located in a separate engine compartment accessible by means of a steel ladder from a door behind the driver's cab. The engine units are mounted upright and immediately over the trucks, thus keeping the length of hydraulic lines to a minimum. Easy access to the engine is available from all sides.

3.1.2 Snow Casting Distance

If it is assumed that the speed while plowing is never below 56 km/h (i.e. 15.6 m/sec), it is possible, by means of the equations in Appendices A and B, to calculate the distance the snow is thrown laterally from the centre of the track.

The calculation, completed in Appendix B, indicates that the snow from the centre of the track will be thrown more than 6 m to the side, providing ample clearance for the vehicle without recirculating the plowed snow on the surface of the plow blade.

3.1.3 Passenger and Baggage Accommodation

Accommodation (F) for twenty passengers is provided on an elevated platform in the centre section of the rail car. Access to this is available from doors on either side of the vehicle (A). (Note that access to the driver's cab (C) is also gained from these doors.) A unisex washroom (B) fitted with chemical toilet and wash basin is provided at the passenger accommodation level.

3.1.4 Heating System

It is estimated that the heating requirements for the remote services vehicle will be of the order of 29 kW to maintain the interior of the car at 24°C with an outside air temperature of -50°C. It is proposed to provide this heat from the engine waste heat by means of a hot water radiator system drawing heat from a heat exchanger in the engine

cooling water recirculating system. Part of the heat thus directed to the passenger area will be released through radiators at floor level and the balance will be ducted overhead by means of a recirculating fan heater. The latter will circulate air at a rate of 79 m^3/min. made up of 51 m^3/min. return air and 28 m^3/min. fresh air.

Hot water for the washroom will be provided by a reservoir drawing heat from heating coils in the engine cooling system.

Emergency back-up heating will be provided by two oil-burning space heaters (6) located one at each end of the passenger compartment. Each of these will have an output capacity of approximately 10.25 kW.

3.1.5 Trucks

Typical truck assemblies are shown in Drawing No. 6. For the hydrostatic transmission used in this case, the arrangement is indicated as Type IA or Type IIA (complete with hydrostatic transmission).

The hydrostatic motor is the Hydromatic Bent Axis type A2F-355 (Item 24). This is flange-mounted to the traction gearbox (27) which is in turn supported by the axle. The torque reaction is provided by an anchor mounted on the truck frame (16).

Mechanical decoupling of the traction gearbox is achieved by means of a pneumatically operated "Airflex" type clutch (23) mounted on the axle. This will permit the axle to freewheel in the case where the remote services vehicle is towed in a train.

The truck is equipped with a complete pneumatically operated brake system.

3.1.6 Miscellaneous

It is intended that power for the internal lighting system and the external head lights, ditch lights, classification and strobe lights, horns, bells, and ventilation fan be drawn from an auxiliary generator driven from the front end of one or each of the main diesel engines.

3.1.7 Discussion

The configuration of the basic remote service vehicle described in this section of the report was designed to satisfy the provisions of the functional performance requirements document (see Appendix J). Section 4.2 of that document requires the vehicle to be capable of negotiating a 76.5 m horizontal curve. It is recommended that the angle of attack for flanged wheels be not greater than 3°. The truck centres of the remote service vehicle configuration in question are 11.0 m apart. A two-axle vehicle would not be suitable under these conditions, since the angle of attack would be approximately 4.1°. Axle centres for a two-axle vehicle on such a curve could not be greater than 7.9 m.

The hydrostatic transmission has certain characteristics which make it very attractive for a vehicle such as the remote services vehicle. The availability of variable-capacity features in both pumps and motors, together with the various types of control, provide a number of drive options. For example, it would be possible to install variable-capacity motors with pressure compensator controls, working in collaboration with variable-capacity pumps. In this way it would be possible to provide an infinitely variable automatic transmission using off-the-shelf items. At the same time, the engine could be run at constant speed, or the engine speed could be controlled by microprocessor, as a function of the power being transmitted, in such a way as to give maximum fuel economy.

In the system shown, the pumps are of variable capacity and the motors are fixed capacity. The pumps are fitted with pressure compensators which vary the capacity in such a way as to maintain constant output pressure as set by a preselected pilot pressure controlled by the driver. (The engines are run at constant speed.) Thus, the size and direction of the torque developed at the driving wheels is set by this pilot pressure. This means that each drive system will seek to deliver the preselected torque, irrespective of the torque generated by other parallel systems. Therefore, it would be unnecessary to synchronize the speeds of the twin engines for load sharing and the control would be simplified.

In the hydrostatic system described, the torque at the driving wheels would be independent of engine speed. This means that the only limitation on driving torque would be the system pressure limiting control. It would be possible to develop full torque at the driving wheels irrespective of the speed of the vehicle right down to zero speed. This means that the vehicle would have excellent acceleration and at the same time high tractive effort at low speed, enabling it to push aside obstructions such as snow overlay and compacted snow furrows caused by highway plows at level crossings.

The engines are enclosed in relatively spacious compartments protected from the elements. Thus, maintenance could be carried out inside, protected from the weather. It is anticipated that maintenance of the main units of the hydrostatic system such as the pumps and motors would be by spare replacement units, allowing those units requiring attention to be returned to the workshop. Replacement of pumps and motors would be a fairly simple maintenance procedure so long as certain simple precautions are taken such as ensuring that the hydraulic lines are kept free of contamination. Temporary protection of disconnected hoses, for example, can be effectively provided by covering the ends with plastic bags.

Location of a baggage area below the passenger compartment makes it possible for this area to be heated by the same heating system. In an emergency, this area could be used for storing stretchers and for transporting injured persons (see Appendix J, Functional Performance Requirements document). The low-slung baggage compartment would facilitate easy access from the side of the vehicle, and in addition emergency access to the baggage area could be provided from inside the passenger compartment.

3.1.8 Cost of Equipment

In a study such as this, engineering of the system is extended only to a degree which makes it possible to adjudge the feasibility of the design. When comparing costs, it is therefore only possible to consider the major components in the system. Some of these have been ascertained with some accuracy for all the various design configurations. The cost of the items for which a figure has not been obtained will be the same for all the options.

Accordingly, for the basic modular version of the remote services vehicle, Table 3 gives a list of costs of the major components which may be used for comparison purposes.

3.2 Option 1

Drawing No. 8 (Appendix G) shows the same vehicle configuration as the basic version described in Section 3.1.1, with the exception that in this case the engines are placed with their axes at right angles to the direction of motion. The engines are of such a size as to make it possible to have the air intake louvres on one side and the exhaust air blower fan on the other side of the vehicle. At the same time, the driver's cab can be increased in size so that it extends across the width of the vehicle. This will give the driver access to the left-hand window of the cab and thus rearward vision on that side, if required.

The cost of the vehicle would be identical with that for the basic version given in Section 3.1.1.

3.3 Option 2

For use on track which is kept free of snow, or for use in areas where there is little or no snowfall, the requirement for two engines may not be justified. In this case, one engine may be removed, together with its associated controls and hydrostatic transmission components. Also, one truck only may be fitted with driving axles. The other may be merely a standard truck.

With only one engine, the performance of the vehicle will be reduced. It will be unable to handle more than a light dusting of snow and its top speed on clear level track will be reduced. Thus, if it is assumed that the transmission is 80 per cent efficient, there will be available at the wheels a tractive power of 250 x 0.8 = 200 kW.

Again using the equations in Appendix D, Table 4 is compiled for travel on clear level track.

It is noted that the top speed would be approximately 91 km/h.

TABLE 3

ESTIMATED COSTS OF EQUIPMMENT - BASIC VERSION

Item	Description	No. Req'd	Cost ($/each)	Total Cost ($)
1	Engine system as per Cummins estimate - Model NTA 855L3 (254 kW @ 2,100 rpm)	2	34,300	68,600
2	Trucks, complete with drive axles, wheels, brake system and controls	2		
3	Blower fan and motor assembly for heating system (Safety Electric Co.)	2	7,300	14,600
4	Main pumps - Hydromatic A4V 250	2	8,600	17,200
5	Main motors - Hydromatic A2F 355	4	5,300	21,200
6	Traction gearbox	4	12,500	50,000
7	Back-up heaters - Vapour Caban 45	2	700	1,400
8	Car body, chassis, drawbars, passenger accommodation, crew accommodation			
9	Heating system	1		
10	Electrical system			
11	Control system			
12	Hydraulic system			
13	Miscellaneous			

TABLE 4

POWER/SPEED RELATIONSHIP FOR OPTION 2

Meters per Second	Km per Hour	Power to Propel Vehicle (kW)
27.4	98.6	250
27.1	97.6	243
26.8	96.5	236
26.5	95.4	229
26.2	94.3	222
25.9	93.2	215
25.6	92.2	209
25.3	91.1	202
25.0	90.0	196
24.7	88.9	190
24.4	87.8	184

With only one engine aboard this type of remote services vehicle, it would be impossible to negotiate snow covered track at a speed much greater than 42 km/h (see Table 2). At this speed the plowing process would, at best, be less efficient. At worst, the snow may not have sufficient inertia to clear the plow blade, and merely pile up ahead of the plow. Snow removal is more efficient, the faster the speed of advance of the plow.[Ref. 1]

The breakdown of cost for Option 2 is given in Table 5.

3.4 Options 3 and 4

Both Options 1 and 2, previously described, feature diesel hydrostatic transmissions. The latter may be replaced by alternative diesel-electric transmission systems.

In the case of Option 3, a twin-engine, diesel-electric system is used. Each engine drives a shunt-wound, self-ventilating traction generator directly mounted to each engine.

Four series-wound traction motors would drive through double-reduction spur gearing. They are carried on axle-mounted gearboxes

TABLE 5

ESTIMATED COSTS OF EQUIPMENT - OPTION 2

Item	Description	No. Req'd	Cost ($/each)	Total Cost ($)
1	Engine system as per Cummins estimate Model NTA 855L3 (254 kW @ 2,100 rpm)	1	34,300	34,300
2	Truck, complete with drive axles, wheels, brake system and controls	1		
3	Standard truck	1		
4	Blower fan and motor assembly for heating system (Safety Electric Co.)	2	7,300	14,600
5	Main pump - Hydromatic A4V 250 (Basic Hydraulics))	1	8,600	8,600
6	Main motor - Hydromatic A2F 355	2	5,300	10,600
7	Traction gearbox	2	12,500	25,000
8	Back-up heaters - Vapour Caban 45	2	670	1,340
9	Car body, chassis, drawbars, passenger accommodation and crew accommodation			
10	Heating system			
11	Electrical system			
12	Hydraulic control system			
13	Miscellaneous			

supported from the truck frames by resilient nose suspensions (see Drawing No. 6, Type 1 (Appendix G)). Safety bars are provided to prevent the motor frames from rotating in the event of motor suspension bolt failure.

Two traction motors are connected in parallel to each generator. Thus, all axles would be driven. Motors are force-ventilated with one blower for each pair of motors.

One 32 volt, 16 cell (167 amp/hour at eight hour rate) lead acid type storage battery will provide engine starting power when engines are shut down. Auxiliary alternators charge the battery.

Two 60 ampere alternators, one mounted on each engine, furnish auxiliary power at constant potential over the full operating range of the engine speed. One alternator has sufficient capacity to supply all control and lighting loads and charge the battery if operating with one engine.

The vehicle is equipped with dual controls for bi-directional operation.

Option 4 would be equipped with only one of the diesel-electric transmission systems mentioned above. Thus, only the two axles of one truck would be driven. The other would be a standard free-wheeling truck.

3.5 Discussion

It is probable that the diesel-electric system is slightly more efficient than the diesel hydraulic system. However, there are other points to be considered in making a final choice.

It is possible that the electrical transmission is more prone to malfunction in snow conditions than the hydrostatic system. The tractive effort available at starting and low speed would be significantly higher in the case of the hydrostatic system. Also, the control system for the diesel-electric option is more complex than the diesel hydrostatic system.

Cost of alternative systems may be of great importance in making a choice. A breakdown of costs is given in Tables 6 and 7.

3.6 Additional Snow Clearing Equipment

The basic version of the remote services vehicle, together with Options 1 and 3, may be used to negotiate snow-covered track to a depth of 7.6 cm ATR. If the snow cover is deeper than this, then either it must be acceptable to operate at reduced speed and therefore at reduced efficiency, or the track must first be cleared by a conventional snowplow.

Deep drifting of the snow may be infrequent for a particular section, but on occasion may happen. If the availability of snow clearing equipment is restricted, then it may be desirable to add a snowblower to these various designs for use in an emergency. It would be possible to attach such a piece of equipment to the remote services vehicle as a temporary measure when and if needed. While negotiating track with heavy snow cover, one of the two engines would be directed to provide power for the blower. The other engine would provide the power for the inching progress required of the vehicle while the blower is working on the snow drift.

Such a unit is shown attached to the basic vehicle in Drawings No. 4 and 5 (Appendix G). The system consists of a snow auger which feeds snow into a pair of blowers which in turn blow the snow to the two sides. In the case of Drawing No. 4, an operator's cab with all controls is located over the auger. In this position, the driver's vision will be unobstructed by the blown snow. Drawing No. 5 shows a version without a separate control cab.

The transmission to the snow blower may be hydrostatic or electrical. As shown, the transmission is hydrostatic and it will be noted that an optional motor for driving a blower is indicated at each end of the vehicle (see item 11). This blower will be capable of handling approximately 3,000 tons of snow an hour at a power input of 240 kW, that is of the same order of power as given out by one of the engines in the designs metioned.

TABLE 6

ESTIMATED COSTS OF EQUIPMENT - OPTION 3

Item	Description	No. Req'd	Cost ($/each)	Total Cost ($)
1	Engine - Cummins NT 855 L4, 250 kW	2))		
2	Traction generators (GE) GT-558	2))		
3	Traction motors (GE) GE 763	4))	227,500	455,000
4	Control system	2))		
5	Axle-mounted gearbox	4)		
6	Trucks, complete with drive axles, wheels, brake system and controls	2		
7	Blower fan and motor assembly for heating system	2	7,300	14,600
8	Back-up heaters - Vapour Caban 45	2	670	1,340
9	Car body chassis, drawbars, passenger accommodation, crew accommodation			
10	Heating system			
11	Miscellaneous			

TABLE 7

ESTIMATED COSTS OF EQUIPMENT - OPTION 4

Item	Description	No. Req'd	Cost ($/each)	Total Cost ($)
1	Engine - Cummins NT855 L4, 250 kW @ 2,100 rpm	1)))		
2	Traction generators (GE) GT-558	1))		
3	Traction motors (GE) GE 763	2))	227,500	227,500
4	Control system	1))		
5	Axle-mounted gearbox	2)		
6	Trucks, complete with drive axles, wheels, brake system and controls	2		
7	Blower fan and motor assembly for heating system	2	7,300	14,600
8	Back-up heaters - Vapour Caban 45	2	670	1,340
9	Car body chassis, drawbars, passenger accommodation, crew accommodation			
10	Heating system			
11	Miscellaneous			

In the case of hydrostatic transmission for the blower, it may be necessary to provide a second pump on each of the engines, dedicated to the blower system. For the diesel-electric system only the electric motors and gearboxes for the blower drive would be necessary as the output from one of the traction generators could easily be switched to the blower system.

Of the two drive systems, it is probable that the diesel hydrostatic is more suitable if the addition of a snowblower is contemplated. The hydrostatic transmission on the main propulsion drive would be capable of providing the requested inching progress of the vehicles when it is blowing snow in a drift.

The approximate cost of the type of snowblower described is not available. However, similar equipment is in use on other snow clearing equipment used on foreign railways. A manufacturer is presently estimating an approximate price for installation on an RSV.

3.7 The Heavy-Duty Remote Services Vehicle

3.7.1 General

In this section a heavier design of remote services vehicle is described. The design was the outcome of a consideration of the first draft specification which required the vehicle to negotiate track covered with a heavy layer of snow up to 30.5 cm ATR. If the flanger clears snow to a depth of 5 cm below the top of the rail, then the full depth of snow to be plowed would be 35.5 cm.

The configuration of the Heavy-Duty RSV is seen on Drawing No. 2 (Appendix G). It consists of a vehicle which combines the features of locomotive, passenger car and snowplow. The snowplowing surfaces and control cab are duplicated at each end so that the vehicle is bi-directional.

The snowplow feature at each end of the vehicle is unlike the conventional snowplow in that the control cab is located over the top of the plowing surfaces. This design was proposed because of the requirement for adequate forward vision for the driver, making it possible to observe the approach of possible hazards, stations, level crossings,

signals, and other vehicles. A conventional snowplow consist may only be run as a "train extra" because in operation a cloud of snow particles thrown up in front of the operator's windscreen obscures forward vision to such an extent that signals cannot be observed with any confidence.

In the case of the Heavy-Dity RSV, the control cab is located immediately above the leading edge of the elevation wedge. The plowed snow is routed along a fluted path which passes below the floor of the cab (the latter forms the upper deflection shield) and exits from the sides of the vehicle well behind the windows. The turbulent snow cloud caused by the plowing process will form behind the driver's cab and thus will not obscure forward vision.

Because of the significant depth of snow to be cleared and the need for adequate speed of operation in this circumstance, it was necessary to provide a relatively large, high-powered engine. This is in the range 640 to 750 kW.

The transmission may be diesel-electric or diesel-hydraulic. Diesel-hydraulic transmission is preferred because of the previously mentioned desirable features of this type of transmission for the service in question and also for the comparative cheapness of the control system.

In the hydrostatic version of this design, a single engine of approximately 750 kW drives one variable-capacity pump via a gearbox on the flywheel housing. This would be connected in a closed-loop circuit with two fixed-capacity hydrostatic motors, one for each of the two axles in the drive truck.

The passenger accommodation, heating and ventilating equipment, washroom and baggage storage facilities are identical with those described in Option 1, with the exception that in this case only one entrance door is provided on one side of the vehicle.

3.7.2 Power Required to Clear Snow

The shape of the plowing surfaces does not permit a simple analysis of the passage of snow over them and such an analysis is outside the

scope of this project. However, an approximate assessment of the power required to clear snow may be made using certain assumptions. Thus, it is noted that the elevation wedge has an angle of 30° with the horizontal, while the vertical wedge forming the point of the plow has an included angle of 40°. It is assumed that the same plowing effect can be achieved by using a planar plowing surface comprising an inclined plane which advances through the snow with an angle of attack, β, equal to half the vertical wedge included angle, i.e. 20°, and with an angle, α, to the horizontal of a magnitude which will present to the advancing snow sheet an apparent incline equal to the 30° angle of the elevation wedge.

Referring to Figure 3 (Appendix H), a simple diagram is presented which is self-explanatory. Using this simplified plowing surface, an approximation to the power requirements is made using the theory presented in Appendix E.

Table 8, together with the graph shown in Figure 5 (Appendix H) is the result of these calculations. In making the calculations, the value of the ratio, C, i.e. the speed decreasing coefficient, has been taken as equal to 0.6,[Ref. 2] it being assumed to be a typical value. Density of snow is assumed to be 240 kg/m^3.

The assumed mass of the vehicle is 54,432 kg and the mass of a trailer 18,144 kg.

It is noted from the graph in Figure 5 (Appendix H) that if the available tractive power is 596 kW, then the speed of the vehicle will be approximately 61 km/h while plowing snow which is 30 cm thick ATR.

A comparison of these figures with the performance figures for the basic version, Section 3.1, indicates that for approximately the same speed the basic version requires only a little less power to clear 7.6 cm of snow ATR from the track. It would appear from this that the Heavy-Duty RSV is a more efficient snow-clearing machine than the small curved-plow surfaces on the front of the basic version remote services vehicle. This is probably due to the fact that a lesser component of forward speed is impressed on the snow in the case of the Heavy-Duty RSV and thus a lesser longitudinal impact force is sustained by the plowing surfaces for the same plow speed.

TABLE 8

APPROXIMATE TRACTIVE POWER VALUES
FOR THE HEAVY-DUTY RSV

Metres per Second	Km per Hour	Tractive Power Required to Clear Snow (kW)	Tractive Power Required to Drive Vehicle (kW)	Total Tractive Power (kw)
30.5	109.7	3,206	333	3,538
27.5	98.8	2,337	251	2,588
24.4	87.7	1,641	185	1,826
21.3	76.8	1,099	132	1,231
18.3	65.8	692	90	783
15.2	54.7	400	60	460
12.2	43.9	205	37	242
9.2	32.9	86	21	107
6.1	21.9	25	11	37
3.1	10.9	3	5	8
0	0	0	0	0

3.7.3 Diesel-Electric System

The Heavy-Duty RSV could be fitted with an alternative diesel-electric system if this type of transmission is preferred. The same engine would be used as for the hydrostatic system and the trucks would be as indicated in Drawing No. 6, Type I or Type II (Appendix G). Cost breakdowns for diesel-hydrostatic and diesel-electric versions are given in Tables 9 and 10, respectively.

3.8 Remote Services Vehicle Consist

At the outset of this project and well in advance of the establishment of the functional performance document (Appendix J), a preliminary design concept of remote services vehicle was drawn up with the purpose of stimulating discussion and generating useful feedback from the interested parties.

It was anticipated, at that stage, that the track over which the remote services vehicle was intended to operate would not be regularly serviced by snowplowing operations during the winter. It would,

TABLE 9

ESTIMATED EQUIPMENT COSTS
HEAVY-DUTY RSV (DIESEL-HYDROSTATIC)

Item	Description	No. Req'd	Cost ($/each)	Total Cost ($)
1	Main engine - Cummins KTA 2300-L 700 kW at 1,800 rpm	1	146,000	146,000
2	Main pump - hydromatic A2P 1000	1	32,800	32,800
3	Traction motor - Hydromatic A2F 1000	2	11,600	23,200
4	Engine flywheel casing gearbox, 1.15:1	1		
5	Traction gearbox, 2.08:1	2	20,000	40,000
6	Axle-mounted clutch - Airflex 11.5 VC 500	1		
7	Twin-axle drive truck complete with air brakes and controls	1		
8	Twin-axle free-wheeling truck complete with air brakes	1		
9	Blower fan and motor assembly for heating system (Safety Electric Co.)	2	7,300	14,600
10	Back-up heaters - Vapour Caban 45	2	670	1,340
11	Car body, chassis, drawbars, passenger accommodation and crew accommodation			
12	Heating system			
13	Electrical system			
14	Hydraulic system			
15	Miscellaneous			

TABLE 10

ESTIMATED EQUIPMENT COSTS
HEAVY-DUTY RSV (DIESEL-ELECTRIC)

Item	Description	No. Req'd	Cost ($/each)	Total Cost ($)
1	Main engine - Cummins KTA 2300-L 700 kW at 1,800 rpm	1	146,000	146,000
2	Traction generator	1		
3	Traction motor	2		
4	Traction gearbox	2	20,000	40,000
5	Twin-axle drive truck complete with air brakes and controls			
6	Twin-axle free-wheeling truck			
7	Blower fan and motor assembly for heating system (Safety Electric Co.)	2	7,300	14,600
8	Back-up heaters - Vapour Caban 45	2	670	1,340
9	Car body, chassis, drawbars, passenger accommodation and crew accommodation			
10	Heating system			
11	Electrical system			
13	Miscellaneous			

therefore, be required to clear its own path when necessary through the typical kind of snowfall for the region, including heavy drifting conditions. Under severe weather conditions it was deemed of primary importance that the vehicle would be capable of making its own way forward or returning, with the schedule times being made approximately flexible in the circumstances.

With this in mind, the vehicle was fitted at each end with double stage rotary snowblower equipment capable of handling the removal of 3,000 tons of snow per hour while moving foward at an appropriate speed (see drawing No. 1 and artist's impression of rotary snowplow remote services vehicle in Appendix G).

At the time it was intended that the snowblower would handle all depths of snow up to its capacity but it was later realized that for relatively light snow cover, a simple small conventional-type plow could be fitted behind each blower as in the case of the basic version described in Section 3.1. It would be very easy to include such simple plowing equipment in the case of this design.

Anticipating the need to transport various flammable materials such as gasoline and propane, as well as snowmobiles, stoves, etc., it was decided, for safety's sake, to split the vehicle into two sections. One section would accommodate approximately forty passengers and the other section would be for the baggage.

Each of the two sections in the consist would have its own engine and powered drive truck. Transmission would be hydrostatic or diesel-electric as in the case of the basic version.

The additional plowing surfaces were added to handle up to 7.6 cm ATR of snow cover, this version of remote services vehicle would be very much like the basic version (see Section 3.3) except for the sectioned vehicle feature, the passenger and baggage capacity, and the duplication of the snowblower as a fixture at each end of the vehicle. The actual power units, transmission, trucks, snowblower equipment, and heating, ventilating and electrical systems would be the same as those components used in the basic version.

As an option, the snowblower equipment could be made detatchable as in the case of the basic version. The two sections of the consist could be separated for summer use when both of the sections, being self-propelled, could be used in separate trains for towing baggage or passenger cars.

An alternative would be provided by a diesel-electric system identical with that provided for in Option 3, mentioned in Secton 3.4. Cost breakdowns for diesel-hydrostatic and diesel-electric versions are given in Tables 11 and 12, respectively.

3.9 Cold-Weather Operation of Hydrostatic Transmission Systems

In extreme cold-weather conditions, hydrostatic transmission systems may require preheating prior to operation. This would be done by using immersion heaters in the oil reservoir to preheat the oil.

Heated oil would be circulated through the hydraulic system by means of the booster pumps, thus charging the system with heated oil and at the same time preheating the main pumps and motors. Subsequent to preheating, the main pumps would be stroked to operate the transmission and heat generated through the normal internal leakage in the hydrostatic units would maintain the system oil temperature at a suitable level. The latter would be controlled at 40°C by means of a thermostat on the air-to-oil cooler.

3.10 Modified Rail Diesel Car (RDC)

The presently used Budd Rail Diesel Car is powered with twin Cummins NT-855-R4 diesel engines continuously rated at 212 kW at 2,100 rpm. These engines have six cylinders and are designed for mounting and operation with cylinders horizontal.

In the RDC the engines are mounted under the underframe of the car between the two trucks. Tractive effort to the drive wheels is transmitted via automatic multi-speed gearboxes and cardan shafts to axle-mounted reduction gearboxes. Two axles, one on each truck, are thus driven.

TABLE 11

ESTIMATED EQUIPMENT COSTS
REMOTE SERVICE CONSIST (DIESEL-HYDRAULIC)

Item	Description	No. Req'd	Cost ($/each)	Total Cost ($)
1	Engine system as per Cummins estimate Model NTA 855-L3	2	34,300	68,600
2	Trucks complete with drive axles, wheels, gearboxes, brake system and controls	2		
3	Standard trucks complete with brakes	2		
4	Blower fan and motor assembly for heating systems	2	7,300	14,600
5	Main pumps - Hydromatic A4V 250 (Basic Hydraulics)	2	8,600	17,200
6	Main motors - Hydromatic A2F 355	4	5,300	21,200
7	Traction gearbox	4	12,500	50,000
8	Back-up heaters - Vapour Caban 45	2	670	1,340
9	Snowblower equipment	2		
10	Car bodies, chassis, drawbars, passenger accommodation, crew acommodation			
11	Heating system			
12	Control system			
13	Electrical system			
14	Hydraulic system			
15	Miscellaneous			

TABLE 12

ESTIMATED EQUIPMENT COSTS
REMOTE SERVICES CONSIST (DIESEL-ELECTRIC)

Item	Description	No. Req'd	Cost ($/each)	Total Cost ($)
1	Engine - Cummins NT 855-L4 250 kW	2		
2	Traction generators (GE) GT-558	2		
3	Traction motors (GE) GE 763	4	227,500 (per set)	455,000
4	Control system	2		
5	Axle-mounted gearbox	4		
6	Trucks complete with drive axles, wheels, brake system and controls	2		
7	Standard trucks	2		
8	Blower fan and motor assembly	2	7,300	14,600
9	Back-up heaters - Vapour Caban 45	2	670	1,340
10	Car bodies, chassis, drawbars, passenger accommodation, crew acommodation			
11	Heating system			
12	Miscellaneous			

The two diesel engines are controlled by the throttle setting and load sharing is accomplished by means of a slave valve on one of the engines.

The whole of the engine transmission system, together with various auxiliary equipment, is mounted under the car.

It is proposed to modify the power unit of the car by replacing the engines with twin Cummins NT-855-L4 upright engines, otherwise identical with the presently used side-mounting engines. These engines are mounted inside the body of the car, immediately over each truck, as shown in Drawing No. 9 (Appendix G). In this location, the engine and hydrostatic pump assembly, together with associated control valves, etc., would be accessible from inside the vehicle, easing the maintenance problems in regions where sheltered maintenance facilities are not available and the climatic conditions for working in the open are unfavourable. At the same time, the location of the main pumps close to the hydrostatic drive motors mounted on the trucks would enable the length of the hydraulic lines to be kept to a minimum.

The transmission would be hydrostatic, with each engine driving a Hydromatic A4V 250 variable-capacity hydrostatic pump connected in closed loop to two Hydromatic A2F 355 fixed-capacity, bent axis motors driving axle-mounted gearboxes (one for each axle) similar to the 2.08:1 ratio gearboxes presently used. The mounting of the traction motors (item 24) is shown in Drawing No. 8, Type III (Appendix G).

While operating on clear track, the top speed of the vehicle would be 60 mph. In this condition, two of the traction motors, one on each truck, would be isolated from the hydraulic circuit and mechanically declutched from the gearbox by means of a coaxial hydraulic clutch (item 25).

Note that each of the four traction motors is fitted with a coaxial clutch. This means that by declutching all the traction motors, the vehicle can be towed in a train without motoring the transmission.

By means of a constant pressure or a constant horsepower control on the pump capacity control, the two engines will automatically share the load. The driver would have control over the setting of the

horsepower or the pressure control of the pump. It would be possible to run the engine at constant speed or to automatically vary the speed in relation to the power demand so as to achieve minimum fuel consumption.

Maintenance of the engines, hydrostatic pumps and auxiliary equipment would be facilitated by the greater accessibility of the engine, etc. Also, since these are located inside the body of the RDC, the maintenance workers would be protected from the elements in inclement weather conditions.

Maintenance and repair of hydrostatic pumps and motors would be by replacement so that faulty units could be returned to the workshops for repair. When changing pumps and motors, certain basic and easy measures would be taken to prevent contamination of the hydraulic system such as temporarily covering loose hose ends with plastic bags and sealing pump and motor parts immediately after removal of the units from the system.

For comparison purposes, an approximate price for the new power unit and transmission is given in Table 13.

TABLE 13

ESTIMATED EQUIPMENT COSTS
MODIFIED BUDD RAIL DIESEL CAR POWER UNIT

Item	Description	No. Req'd	Cost ($/each)	Total Cost ($)
1	Main engines - Cummins NT-855-L4	2	30,000	60,000
2	Main pumps - Hydromatic A4V-250	2	8,600	17,200
3	Traction motors - Hydromatic A2F-355	4	5,300	21,200
4	Electromagnetic clutches Ortlinghaus O-010-055-47-064	4	1,800	7,200
5	Axle-mounted gearbox, 2.08:1 Safety Electric Model 8	4	17,700	70,800
6	Hydraulic system and controls			
7	Modifications to car body			

3.11 Light Rail Vehicles (Railbus)

There are a number of self-propelled light rail vehicles available from suppliers in Europe and Japan. Since many of these vehicles are similar in appearance and design of the passenger compartment to highway buses, such light rail vehicles are often referred to as railbuses. The term must be used carefully, since there are also hybrid vehicles made by converting a production highway bus to accept a railway suspension and running gear.

Light rail vehicles cover a range of capabilities, from very lightweight, single-unit vehicles with top speeds of 60 km/h to heavier, multi-unit consists with top speeds approaching 140 km/h. Many of the light rail vehicles on the market were designed for the suburban commuter market or for the very-short-haul intercity market. A review of the offerings from individual manufacturers, however, shows a definite trend toward provision of units designed for heavier service such as would be required for the Canadian Remote Service and Regional markets.

While there are a number of candidate light rail vehicles that might bear further examination, two entries in the market are of particular interest. They are the BREL/Layland vehicle from the United Kingdom and the Hungarian Ganz-Mavag/Ikarus vehicle.

3.11.1 BREL/Leyland

The BREL vehicle is 15.3 m long, with a narrow (2.6 m) body. It weighs 21 tonnes and is powered by a 162 kW diesel power plant. It has two single axles with a flexicoil suspension. While the vehicle has been designed and engineered as a railway vehicle, the body, power plant and many of the subsystems are based on a proven, standard British Leyland bus design.

Single unit vehicles have been in operation in the United Kingdom since 1981. A two-unit married-pair prototype has also been developed.

The single unit is bi-directional with a control cab at each end; the double-unit is similarly bi-directional with one cab in each unit. The

manufacturer states that up to four units may be combined into a consist. Two consists can be operated as a Multiple Unit from a single control cab. The manufacturer also states that a more powerful engine allowing higher-speed operation will be available.

While the BREL vehicle is equipped with commuter-type seating, it can also accommodate the "standard" North American heavy rail type of seat with a capacity of 35-40 seats per single unit. No substantive cargo space is available in the BREL vehicle. For remote service applications where oversize "baggage" must be accommodated, it would be necessary to operate one unit with a modified interior. Additional access doors would be necessary, and it is not clear whether this would entail major modifications to the size of the car body.

The manufacturer states that the BREL vehicle is designed for an ambient temperature of -40°C and is capable of operating on 4 per cent grades. Fuel consumption is estimated in the range of 8-10 mpg. Maintenance and servicing requirements are estimated to be lower than those for conventional railway equipment and, since many of the subsystems and components are derived from standard bus designs, at least some maintenance and servicing could be carried out in other than specialized railway shops. This feature is potentially of great value, since most remote communities have one or more persons familiar with standard highway diesel maintenance.

From a brief examination of the technology and specifications of the BREL vehicle, it appears that the operating and maintenance costs would be lower than those of conventional locomotive-hauled trains or RDCs of a similar capacity. A preliminary estimate of the capital cost is not available. However, based on the technology and design, it would be expected to be lower than that of conventional rail vehicles of a similar capacity.

Limited revenue-service testing programs are either scheduled or under way for the BREL vehicle on some commuter lines in the United States. It is understood that the vehicle either complies with or can be easily modified to comply with most North American safety standards and other product specifications. It does not and cannot conform to the 800,000 lb AAR buff load requirements. Its acceptance for testing on American lines indicates willingness on the part of regulatory and

operational authorities to at least consider the possibility of permitting shared-line operations of non-conforming vehicles.

Further examination of the BREL vehicle for application in Canada seems warranted. It would be useful to monitor the tests in the United States, particularly with respect to customer acceptance and actual vehicle performance and maintenance experience. These tests, however, will provide little, if any, information on the performance of the vehicle in cold weather and snow conditions typical of Canadian remote services.

3.11.2 Ganz-Mavag/Ikarus

The Ganz-Mavag/Ikarus vehicle is similar to, but somewhat smaller than, the BREL vehicle. Each unit is 12.1 m long and 2.48 m wide and weighs 26 tonnes. It is designed for either two-unit married pairs or for three-unit consists. It is powered by a 254 kW diesel engine, and has an estimated top speed of 100 km/h. It uses single axles with flexicoil suspensions. Like the BREL vehicle, it appears that the Ganz-Mavag vehicle is being engineered for railway operations, but with many control and accommodation components based on bus design.

Because of the smaller body size, seating capacity is somewhat less than the BREL vehicle. No information on cargo capacity is available. Presumably, one unit in the consist would require modification as a baggage car.

The Ganz-Mavag vehicle is only in the prototype stage. The reported initial target market is Southeast Asian and European branch lines.

Other design details and specifications are unknown.

On net, further examination and monitoring of the prototype program of the Ganz-Mavag vehicle for possible Canadian applications seems warranted.

3.12 The Wickham Rail Car

A light rail vehicle which may be considered as a possible design option for some limited aspects of the remote services operation is produced by D. Wickham and Company Limited of England. It is called the "Type 38 Inspection or Gang Car." Details are given in Appendix I.

The Wickham car must be considered in the context of the functional requirements for the RSV which are reproduced in full in Appendix J. Accordingly, it is noted that the Wickham car by itself does not have adequate passenger accommodation. Nor does it appear to include on-board washroom facilities.

The 86 km/h top speed of the vehicle on clear level track falls short of the required 100 km/h specified for the RSV, and with the engine power provided, namely 80 BHP at 2,800 rpm, it would be unable to cope satisfactorily with the amount of snow cover specified at any reasonable speed. Further, it is unlikely that the Wickham car could negotiate satisfactorily the type of compacted snow furrows set up by highway plows at level crossings.

It is possible that the vehicle could be modified to provide useful service in sections which are otherwise adequately cleared of snow; or where snowfall is infrequent. In this case, it would be necessary to increase the speed of the car and also to increase passenger accommodation and baggage space. The latter may be achieved by operating a number of such rail cars as a consist, or by providing a personnel trailer and a baggage trailer.

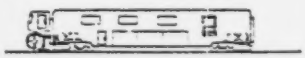
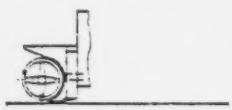
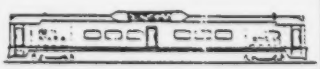
In general, it would appear that the Wickham rail car is not adequate to provide the type of service required.

The approximate cost of a Wickham Type 38 Inspection Gang Car, together with personnel trailer and baggage trailer, suitable for operation on cleared track in Canadian winter conditions, would be approximately $165,000. This price would include freight charges to Montreal and is based on an order for ten cars.

Each unit would be capable of accommodating 26 passengers (eight passengers including driver in the Inspection Car, and 18 passengers in the personnel trailer) and 2,500 kg of baggage.

The passenger capacity could be increased to 33, including the driver, by substituting a Wickham 38 Gang Car instead of the Inspection Car. In this case there may be some increase in the cost quoted for the full system.

4. DESIGN COST COMPARISON

No.	Description	Dwg No.	Option	Schematic Picture	Maximum Speed on Clear Track (km/h)	No. of Passengers	Cargo Capacity (cu.ft)	Snow Clearing				
								Capacity (metric) (tonnes/h)	Width (m)	Plowing Height (cm ATR) / Speed (km/h)	Drift Height (m ART) / Speed (km/h)	
I	1 car, 2 levels (1 level for passengers and 1 for cargo) Drivers cabin at both ends	7&8	Basic Version and Option 1		100	20-30	850	5,000	3	7.6 / 56	- / -	Permane snowpl
II	1 car, 2 levels (1 level for passengers and 1 for cargo) Drivers cabin at both ends	7&8	Option 2		89	20-30	850	0	0	0 / 90	- / -	
III	1 car, 2 levels (1 level for passengers and 1 for cargo) Drivers cabin at both ends	7&8	Option 3		100	20-30	850	5,000	3	7.6 / 56	- / -	Permane snowpl
IV	1 car, 2 levels (1 level for passengers and 1 for cargo) Drivers cabin at both ends	7&8	Option 4		89	20-30	850	0	0	0 / 90	- / -	
V	1 car, 2 levels (1 level for passengers and 1 for cargo) Drivers cabin at both ends	6	Basic Version Options 1 & 3		100	20-30	850	3,000	3	7.6 / 56	1.5 / 2	Snowbl attached of vehi Commat blower cabin w trols. and mov
VI	1 car, 2 levels (1 level for passengers and 1 for cargo) Drivers cabin at both ends	5	Basic Version Options 1 & 3			20-30	850	3,000	3	7.6 / 56	1.5 / 2	Snowpl attached of vehi Commat blower. tach or end
VII	1 car, 2 levels (1 level for passengers and 1 for cargo) Drivers cabin at both ends	2			100+	20-30	850	14,000	3	30 / 60	- / -	Built-in both en design snow re cabin
VIII	Commut. 2 units (1 for passengers and 1 for cargo)	1			100	30-40	2,000	3,000	3	7.6 / 56	2 / 1.5	Built-in blower
IX	Modified RDC 1 car, 1 level	9			100+	30-40	1,260	0	0	0 / 100	0 / 100	Gear b

Type of Equipment			Two-Axle Trucks			Power Unit: Transmission					Price, incl Cooling System			Remarks
Description	Type of Transmission	Price	Drive / Price	Idler / Price	Total Price	Type	Approx. Price	Type of Engine	No. per Vehicle	Total Power (kW)	Each	Per Vehicle	Total Price	
Permanently-attached snowplow, both ends			2	0		diesel-hydrostatic	$100,000	Cummins NTA-855-L3 254 kW	2	508	$ 34,270	$ 68,540		
			1	1		diesel-hydrostatic	$ 50,000	Cummins NTA-855-L3 254 kW	1	254	$ 34,270	$ 34,270		
Permanently-attached snowplow, both ends			2	0		diesel-electric	$390,000	Cummins NTA-855-L3 254 kW	2	508	$ 34,270	$ 68,540		
			1	1		diesel-electric	$195,000	Cummins NTA-855-L3 254 kW	1	254	$ 34,270	$ 34,270		
Snowblower unit attached to front end of vehicle. Opt.1&3. Consists of auger, blower & drivers cabin with all controls. Easy to detach and move to other end.	electrical		2	0		diesel-electric	$390,000	Cummins NTA-855-L3 254 kW	2	508	$ 34,270	$ 68,540		
	hydrostatic		2	0		diesel-hydrostatic	$100,000							
Snowblower unit attached to front end of vehicle. Opt.1&3. Consists of auger and blower. Easy to detach or move to other end	electrical					diesel-electric	$390,000	Cummins NTA-855-L3 254 kW	2	508	$ 34,270	$ 68,540		
	hydrostatic					diesel-hydrostatic	$100,000							
Built-in snowplow at both ends. Specially designed to discharge snow behind drivers cabin			1	1		diesel-electric	$200,000	Cummins KTA-2300-L 700 kW	1	700	$146,000	$146,000		
			1	1		diesel-hydrostatic	$120,000							
Built-in auger and blower	electrical		2	2		diesel-electric	$390,000	Cummins NTA-855-L3 254 kW	2	508	$ 34,270	$ 68,540		
	hydrostatic					diesel-hydrostatic	$100,000							
Gear box similar			2	0		diesel-hydrostatic	130,000	Cummins NTA-855-L4 212 kW	2	425	$ 30,000	$ 60,000		

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2. "A Study on the Resistance of Snowplowing and the Running Stability of a Snow Removal Truck." Terutoshi Kaku, Hokaido University of Japan. Snow Removal and Ice Control Research, Special Report 185, Transportation Research Board, National Academy of Sciences, Washington, D.C. 1979.

3. "Snow and Buildings." Boyd, Schriver & Taylor Handbook of Snow, Pergamon Press.

APPENDIX A

GEOMETRY OF MOVEMENT OF SNOW ON CURVED PLOW BLADES

Figure 1 (Appendix H) shows a diagram of a curved plow surface advancing into snow with velocity, V, at an angle of attack, β. It is assumed that no compaction of snow takes place while travelling over the surface of the plow but that there will be a reduction in relative velocity of snow to plow surface of 40 per cent.[Ref. 1] This means that the velocity of exit of the snow sheet from the plow blade will be reduced from the velocity of the blade, V, by a factor C = 0.6.

The action of the plow blade, ABCD, on a particle at the tip of the blade in position K is considered. If it were left undisturbed by the passage of the blade, it would reach the relative position, P, as the blade moves forward a distance S. However, because the particle does pass over the blade, there is a slowing down of the particle relative to the blade, so that if this is taken into account then the relative position of the undisturbed particle would be at point P'.

Now, considering the passage over the blade, it is noted that the length, b, is equal to the arc length, b'. From this point a consideration of the geometry of the diagram results in the following mathematical argument:

$$x = S - (SC - (SC \sin \beta - r \sin \alpha) \sin \beta)$$

$$\frac{dx}{dt} = \frac{ds}{dt} - (\frac{ds}{dt} C - (\frac{ds}{dt} C \sin \beta - r \cos \alpha \frac{d\alpha}{dt}) \sin \beta) \qquad (1)$$

$$\alpha = \frac{b'}{r} = \frac{SC}{r} \sin \beta$$

$$\frac{d\alpha}{dt} = \frac{C}{r} \frac{ds}{dt} \sin \beta \qquad (2)$$

Substitute (2) in (1) and put $\frac{ds}{dt} = V$, $\frac{dx}{dt} = V_x$

Therefore, $Vx = V - (CV - (CV \sin \beta - CV \cos \alpha \sin \beta) \sin \beta)$

Therefore, $Vx = V (1 - C (1 - \sin^2 \beta (1 - \cos \alpha)))$ (3)

$z = [CS \sin \beta - r \sin \alpha] \cos \beta$

$\frac{dz}{dt} = [C\frac{dS}{dt} \sin \beta - r \cos \alpha \frac{d\alpha}{dt}] \cos \beta$

But $\alpha = \frac{SC}{r} \sin \beta$

Therefore, $\frac{d\alpha}{dt} = C\frac{dS}{dt} \frac{\sin \beta}{r}$

Therefore, by substitution:

$\frac{dz}{dt} = [C\frac{dS}{dt} \sin \beta - C\frac{dS}{dt} \sin \beta \cos \alpha] \cos \beta$ (4)

But $\frac{dz}{dt} = Vz$ and $\frac{dS}{dt} = V$

Therefore, $Vz = CV \sin \beta \cos \beta [1 - \cos \alpha]$ (5)

$y = r (1 - \cos \alpha)$

$\frac{dy}{dt} = r \sin \alpha \frac{d\alpha}{dt}$

But, $\alpha = \frac{b'}{r}$

and $b' = SC \sin \beta$

Therefore, $\frac{d\alpha}{dt} = \frac{C \sin \beta}{r} \frac{ds}{dt}$ (7)

Substitute (7) in (6) to get:

$$\frac{dy}{dt} = C \frac{ds}{dt} \sin \alpha \sin \beta$$

and since $\frac{dy}{dt} = Vy$ and $\frac{ds}{dt} = V$, this may be written:

$$Vy = CV \sin \alpha \sin \beta \qquad (8)$$

In summary, the three components of velocity at exit from the blade are expressed by equations (3), (5) and (8), i.e.

$$\left.\begin{aligned} Vx &= V\,(1 - C\,(1 - \sin^2 \beta\,(1 - \cos \alpha))) \\ Vz &= CV \sin \beta \cos \beta\,[\,1 - \cos \alpha\,] \\ Vy &= CV \sin \alpha \sin \beta \end{aligned}\right\} \qquad (9)$$

APPENDIX B

TRAJECTORY OF SNOW EXITING PLOW BLADE

The purpose of the plow is to throw the snow to one side of the track. The forward velocity, Vx, imparted to the snow should be as small as possible, while the magnitude of the vertical and lateral components, Vy and Vz, should be adequate to cause the snow to be flung clear of the advancing vehicle.

The trajectory of the snow leaving the blade at right angles to the direction of travel may be calculated from the component velocities, Vy and Vz. Thus, the angle of exit in this plane is calculated:

$$\theta = \tan^{-1} \frac{Vy}{Vz} \qquad (1)$$

$$Vyz = \sqrt{Vy^2 + Vz^2} \qquad (2)$$

The cast distance, R, is calculated using the following equation:

$$R = K^2 \frac{Vyz^2}{g} \sin 2\theta \qquad (3)$$

and substituting for "Vyz" from (2), and for "θ" from equation (1):

$$R = K^2 \frac{(Vy^2 + Vz^2)}{g} \sin \left[2 \tan^{-1} \left(\frac{Vy}{Vz}\right) \right] \qquad (4)$$

in which the factor K = 0.7 makes a correction for wind resistance.

Calculation of snow casting distance "R" with:

$$V = 15.6 \text{ metres/sec. (56 km/h)}$$

$$\alpha = 135°$$

$$\beta = 51°$$

Vy and Vz are calculated from equation 9 in Appendix A:

$Vy = 0.6 \times 15.6 \times \sin 135° \times \sin 51° = 5.1$ metres/sec.

$Vz = 0.6 \times 15.6 \times \sin 51° \times \cos 51° \times [1 - \cos 135°]$
$= 7.8$ metres/sec.

$$\theta = \tan^{-1} \frac{Vy}{Vz} = \tan^{-1} \frac{5.1}{7.8} = 33.2°$$

$$\text{Therefore, } R = \frac{0.7^2 (5.1^2 + 7.8^2)}{9.81} \sin (2 \times 33.2°)$$

$= 3.97$ metres (13 ft)

APPENDIX C

POWER REQUIRED TO PLOW SNOW

The power required to plow snow is calculated from the rate of change of momentum of the snow sheet in the direction of travel.

If the cross-sectional area of the channel being plowed is given the symbol A and the density of snow is ρ, then the effort, Fx, required to impart the forward momentum to the snow is calculated by multiplying equation for Vx in eqations (9), Appendix A, by the mass flow rate:

$$Fx = \frac{dM}{dx} V (1 - C (1 - \sin^2 \beta(1 - \cos \alpha)))$$

Therefore, $Fx = \rho AV^2 (1 - C(1 - \sin^2 \beta (1 - \cos\ )))$ (1)

The power required to plow the snow is calculated by multiplying the equation for Fx (equation (1)) by the forward velocity of the vehicle, i.e.

$$\text{Power} = \rho AV^2 (1 - C (1 - \sin^2 \beta (1 - \cos \alpha))) \quad (2)$$

APPENDIX D

POWER REQUIRED TO DRIVE VEHICLE

The power required to drive the vehicle along level track is calculated using the Modified Davis Formula:

$$R = 7.35 \times 10^{-3} M + 80 N + 8.23 \times 10^{-3} MV + 159.7 AV^2 \text{ (leading car)}$$

$$R = 7.35 \times 10^{-3} M + 80 N + 8.23 \times 10^{-3} MV + 22.55 AV^2 \text{ (trailing car)}$$

where: R = resistance in Newtons

M = mass of vehicle in kg

V = velocity in km/minute

N = number of axles

A = cross-sectional area in square metres

Power = RV/60 watts

APPENDIX E

GEOMETRY OF MOVEMENT OF SNOW OVER A FLAT PLOW BLADE

The diagram shown in Figure 2 (Appendix H) shows a flat plow blade, ABC, inclined at an angle, α, to the horizontal, advancing through the snow at velocity V, at an angle of attack β.

A particle at point K presently at the tip of the wedge, if undisturbed by the passage of the blade over it, would reach the relative position, P, as the blade advances a distance S. Since in the actual case the relative particle speed would be less than the velocity of the blade, V, by the decreasing factor, C, the actual relative distance of the undisturbed particle would be at point P'. But the particle passes over the blade so that in actual fact it reaches a point, P'', on the surface of the blade. The vertical projection of the point, P'', on the incline is at point P''' at an elevation, y, above the ground surface level.

Referring to the diagram, the following argument is made:

$$x = S - (SC - SC \sin^2 \beta (1 - \cos\alpha))$$

$$= S - SC (1 - \sin^2 \beta (1 - \cos\alpha))$$

$$Vx = \frac{dx}{dt} = V - CV (1 - \sin^2 \beta (1 - \cos\alpha)) \quad (\text{since } \frac{dS}{dt} = V)$$
$$= V (1 - C (1 - \sin^2 \beta (1 - \cos\alpha)))$$

Fx = effort in x direction

= rate of change of momentum in x direction = $\frac{dM}{dt} Vx$

Therefore, $Fx = \rho AV^2 (1 - C (1 - \sin^2 \beta (1 - \cos\alpha)))$

Therefore, power = V Fx

$$= \rho A V^3 (1 - C (1 - \sin^2 \beta (1 - \cos \alpha)))$$

where: ρ = density of snow

A = cross-sectional area of snow being plowed

V = velocity of plow

C = velocity decreasing coefficient

β = angle of attack

α = angle of flat plow surface to horizontal.

Also, $y = CS \sin \beta \sin \alpha$,

therefore, $Vy = \frac{dy}{dt} = CV \sin \beta \sin \alpha$

and $z = CS \sin \beta (1 - \cos \alpha) \cos \beta$

Therefore, $Vz = \frac{dz}{dt} = CV (1 - \cos \alpha) \sin \beta \cos \beta$

APPENDIX F

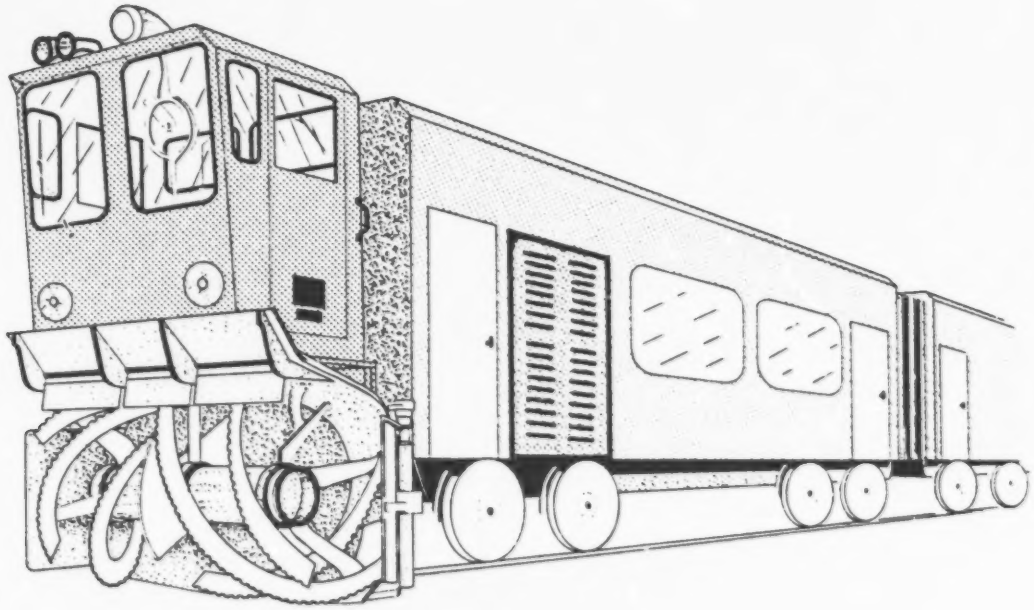
PARTS DESCRIPTION, DRAWINGS NO. 4, 5, 6, 7 AND 8

Item	Description	Reference Information	Qty	Remarks
1	Car body	Assembly	1	
2	Air intake louvres	Assembly	2	
3	Engine exhaust system	Assembly	2	
4	Diesel engine with heat exchanger and auxiliary pump for car heating system		2	Cummins Model NTA-855-L3 254 kW @ 2100 rpm
5	Roof-mounted radiator with louvres	Assembly	2	Cummins
6	Heater	Assembly	2	Vapor Caban Model 45, 10,000 watts
7	Variable displacement pump	Assembly	2	Rexroth Model A4V, 250 40 MPa max. pressure
8	Window	Assembly	10	
9	Driver's seat	Assembly	2	
10	Snowblower mounting flange	Assembly	2	
11	Fixed-displacement hydraulic motor	Assembly	6	Rexroth Model A2F, 355
12	Coupler	Assembly	2	AAR standard
13	Plow blade deploying cylinder	Assembly	2	
14	Plow blade	Assembly	2	

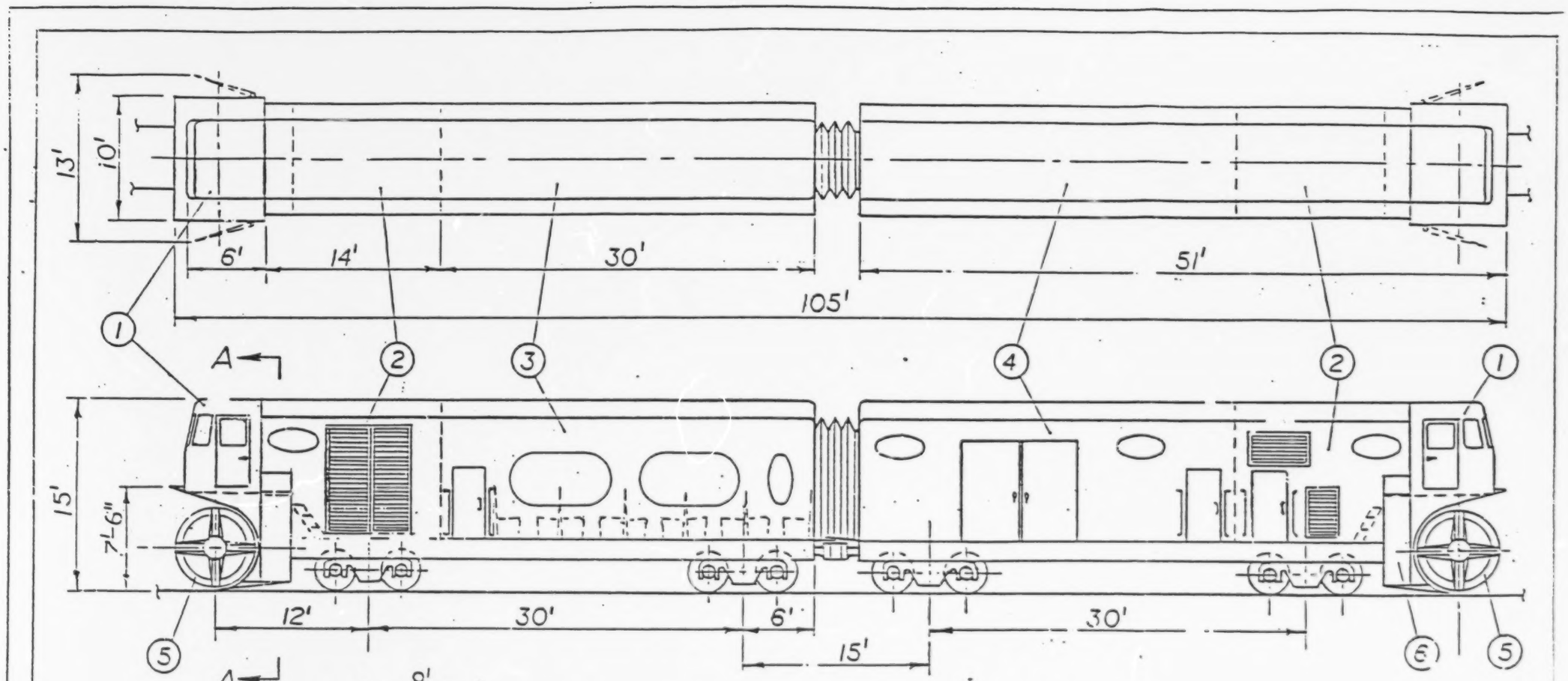
Item	Description	Reference Information	Qty	Remarks
15	Drop side freight bay covers and loading ramps	Fabrication	3 each side	
16	Truck frame	Assembly	2	
17	Blower	Assembly	1	Rolba
18	Auger	Assembly	1	Rolba
19	Snowblower driver's cabin	Assembly	1	Rolba
20	Passenger seat	Assembly	10	
21	83.8 cm dia. wheel		8	
22	Electric traction motor	Assembly	4	
23	Pneumatic clutch	Assembly	4	
24	Hydrostatic traction motor	Assembly	4	
25	Hydraulic clutch	Assembly	4	
26	Traction gearbox	Assembly	4	Model 8 "Spicer"
27	Traction gearbox	Assembly	4	General Electric
28	Traction gearbox	Assembly	4	American Hoist and Derrick Co.
A	Entrance/exit		2	
B	Toilet		1	
C	Driver's cabin		2	
D	Baggage compartment		1	900 cu.ft.
E	Engine room		2	
F	Passenger saloon			20 seats

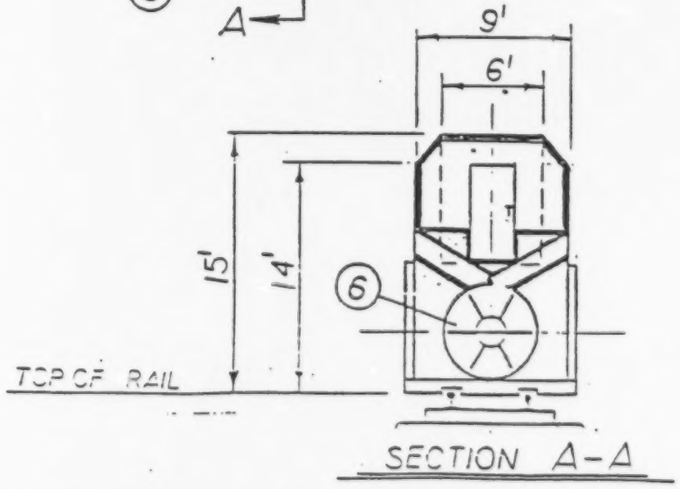
APPENDIX G

DRAWINGS



Artist's Impression of Rotary Snowplow Remote Services Vehicle





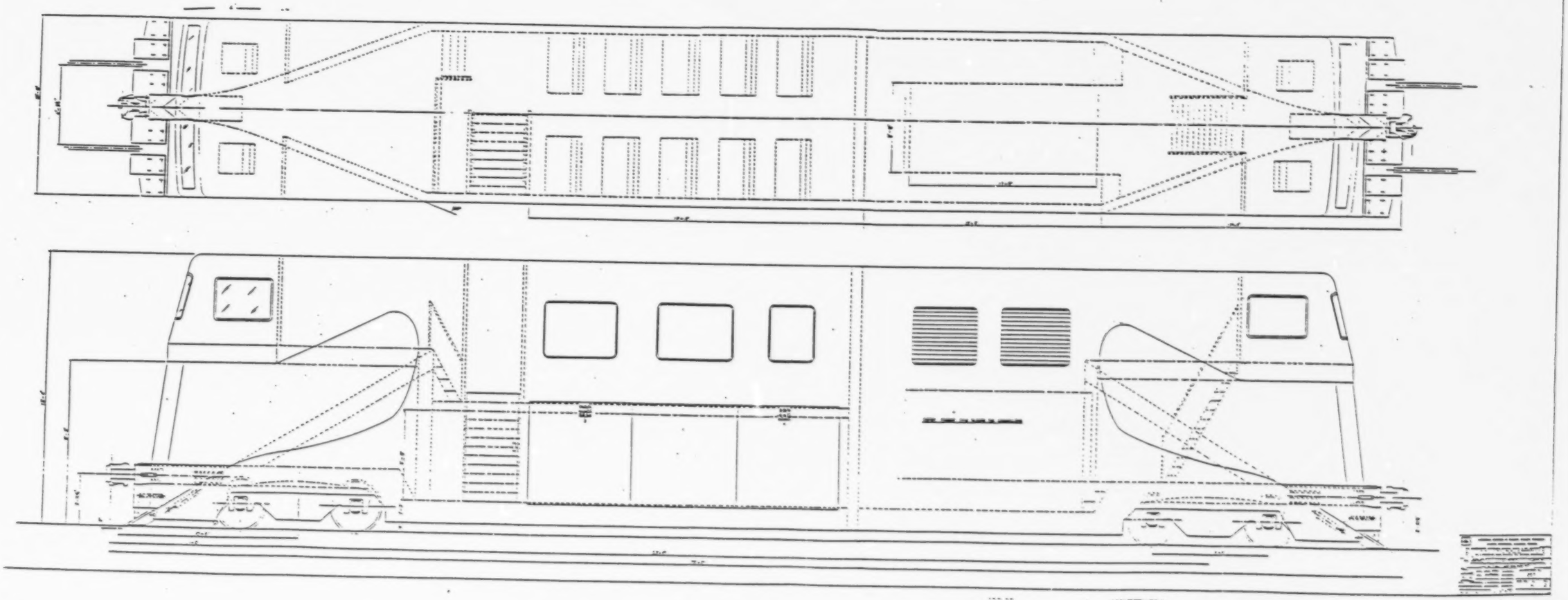
SECTION A-A

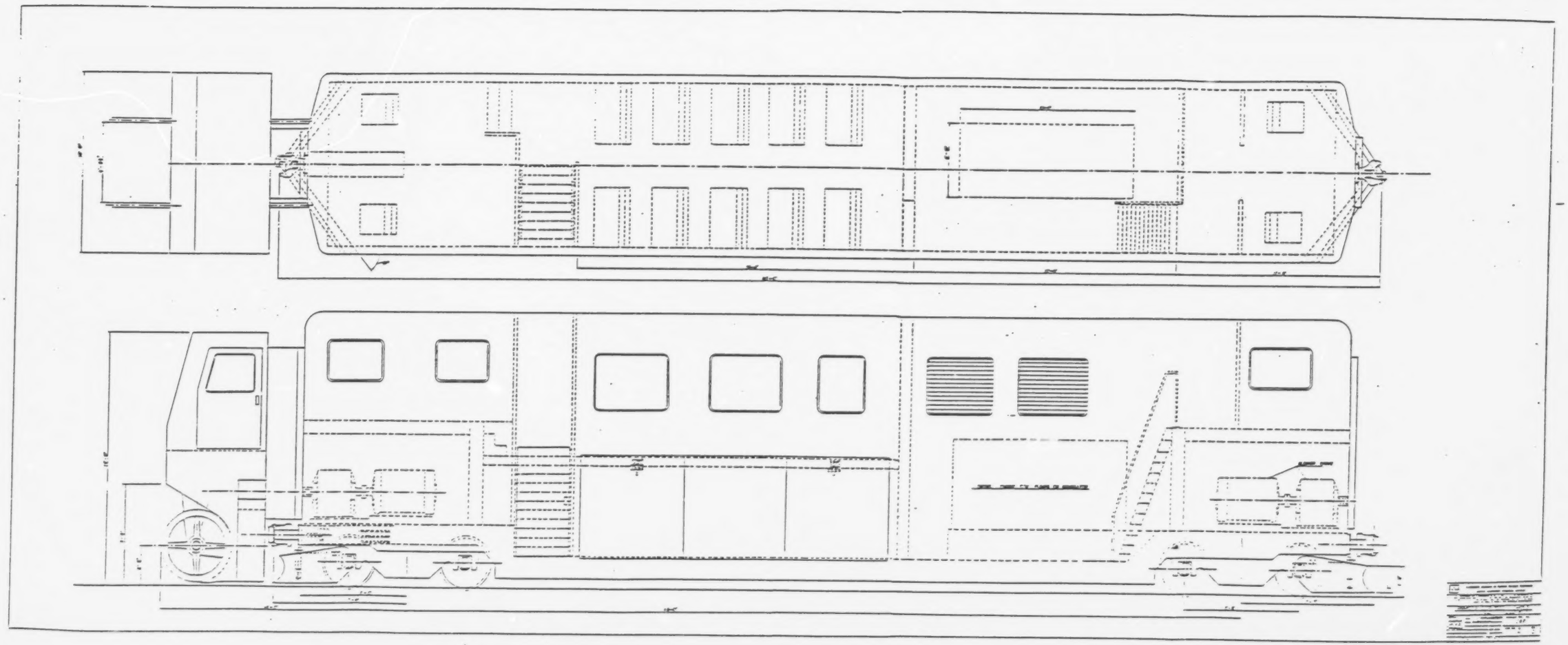
TECHNICAL DATA

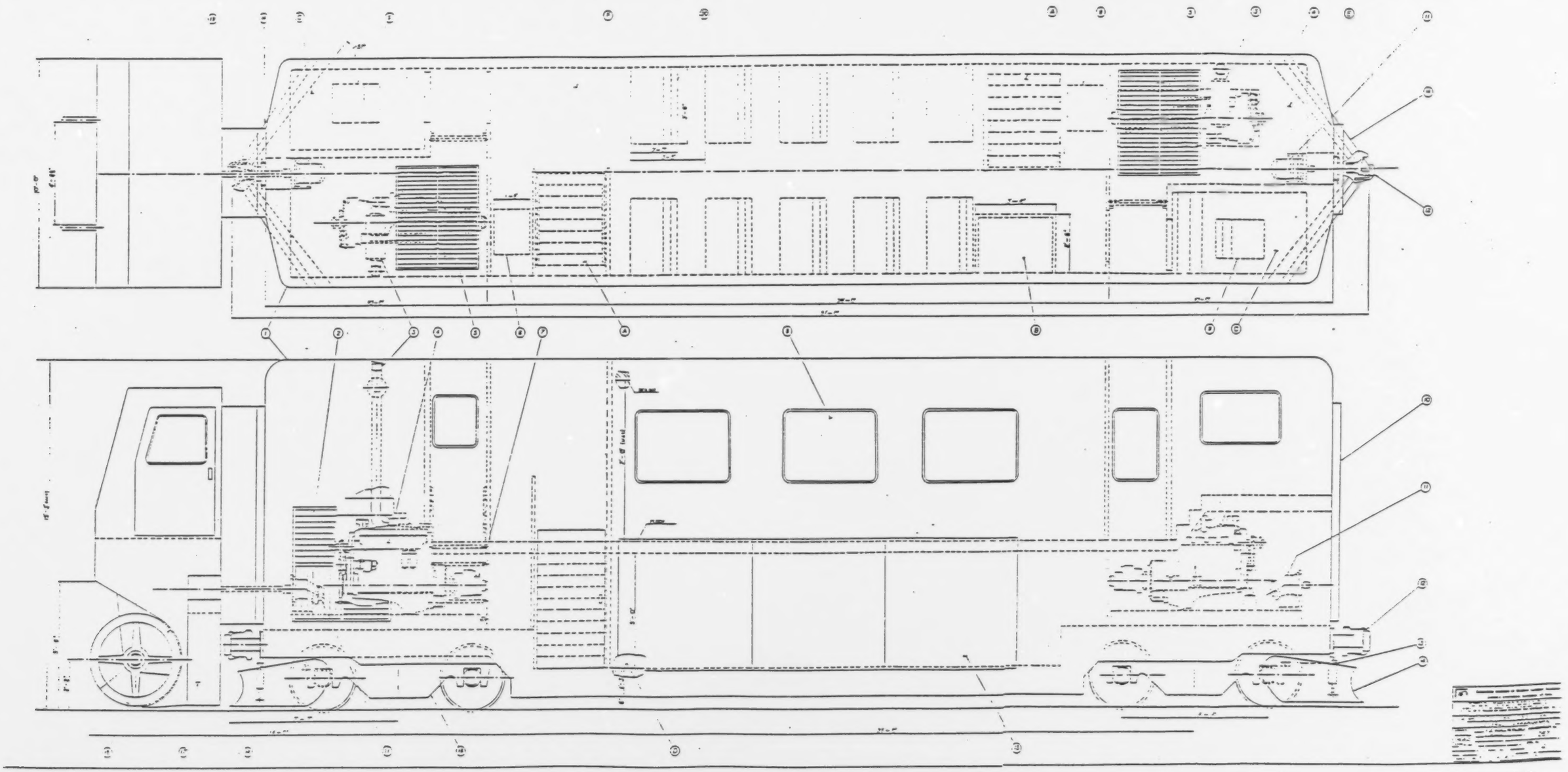
MAXIMUM SPEED	100 km/h
SNOW REMOVAL SPEED	0.5-30 km/h
SNOW REMOVAL CAPACITY	UP TO 6000 t/h
CLEARING WIDTH OF SNOW	10-13 ft.
CLEARING DEPTH OF SNOW	8 ft. max.
TARE WEIGHT	UP TO 100000 KG

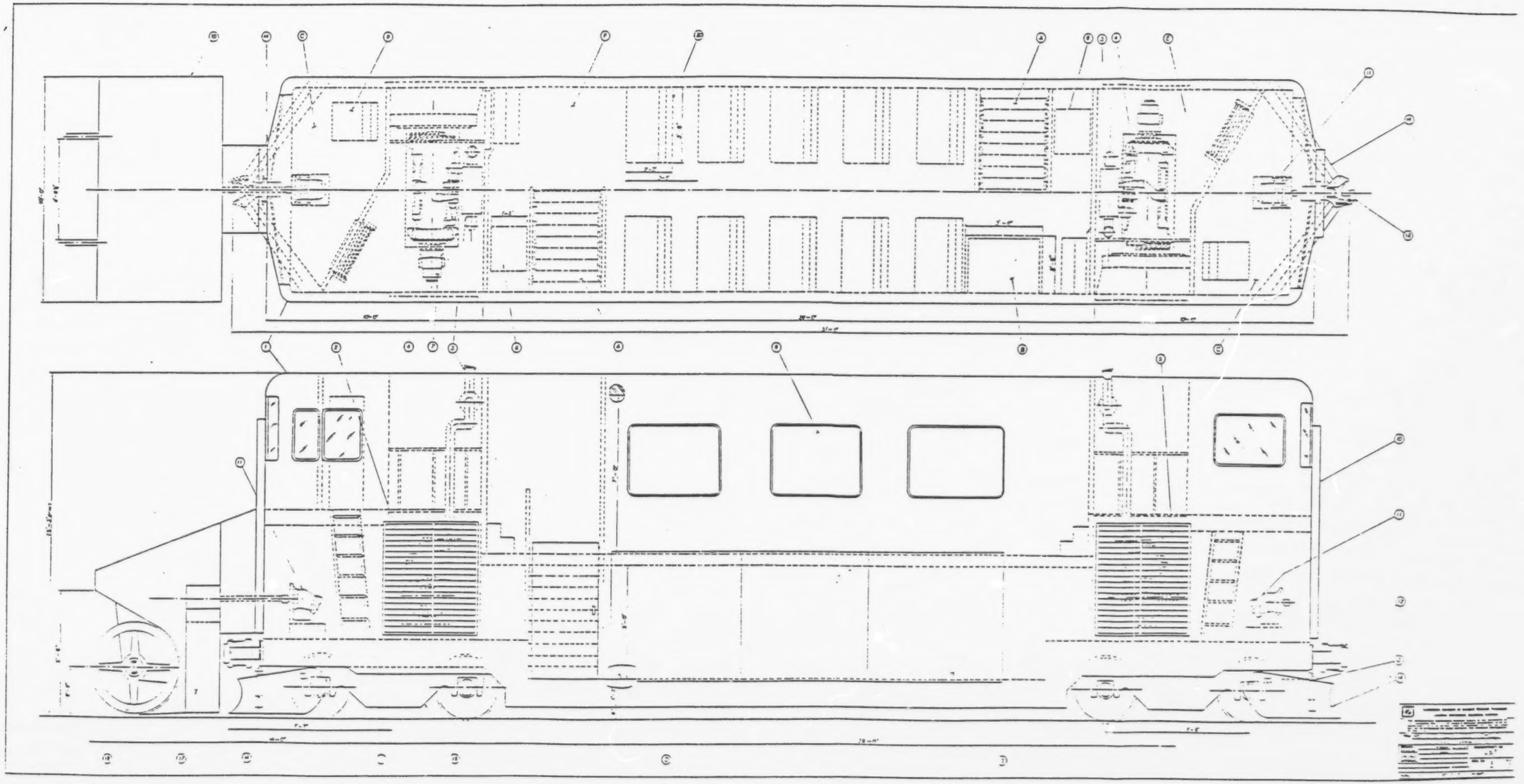
1. ENGINEER'S CABIN
2. ENGINE ROOM
3. PASSENGERS' SALON
4. CARGO
5. AUGER
6. SNOW BLOWER (THROWER)

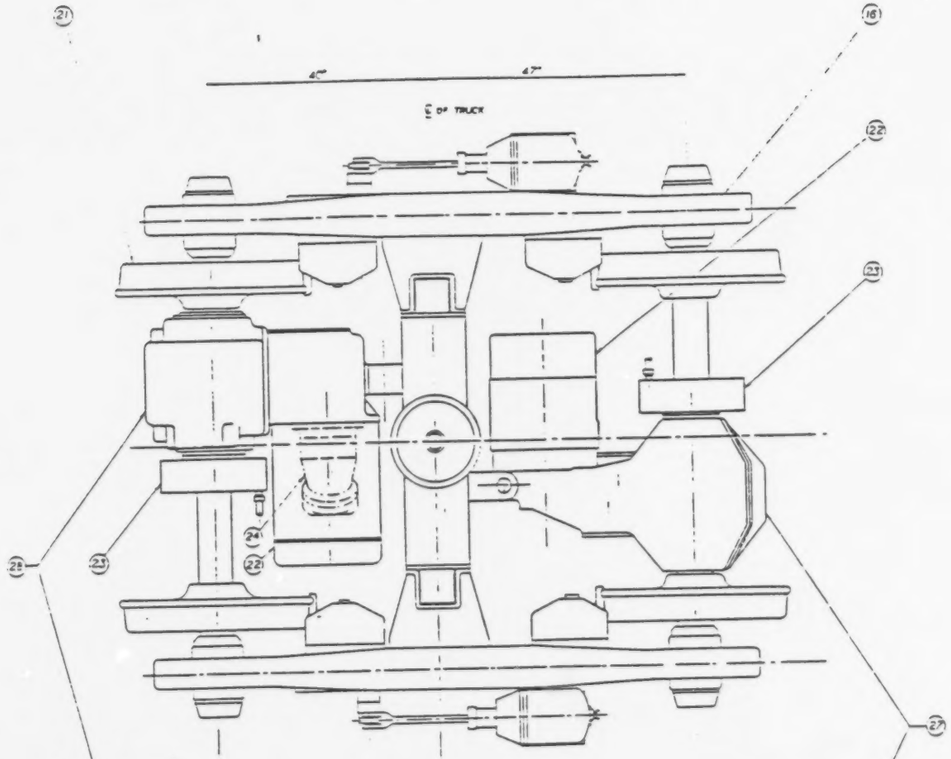
REMOTE SERVICES VEHICLE	PRO 267	CIGGT	DWG Nº 1



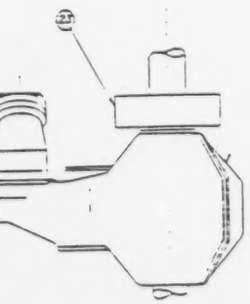




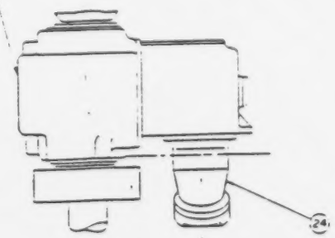




TYPE I (c/w ELECTRIC TRACTION MOTOR)

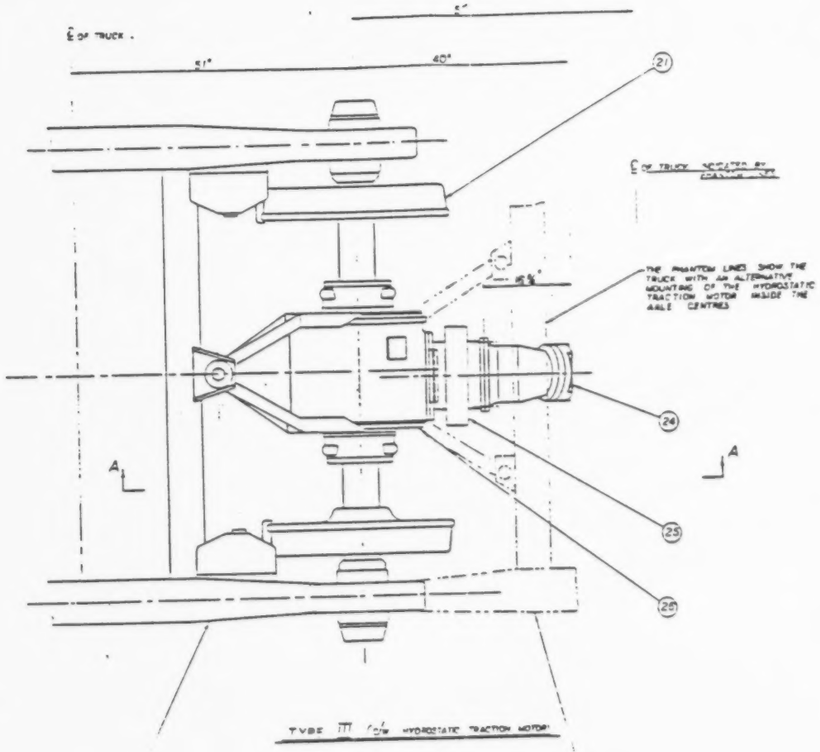


TYPE II (c/w ELECTRIC TRACTION MOTOR)

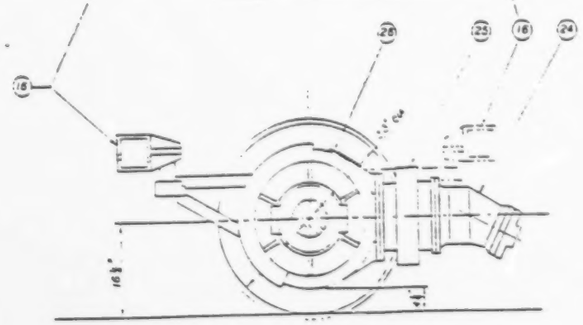


TYPE I (c/w HYDROSTATIC TRACTION MOTOR)

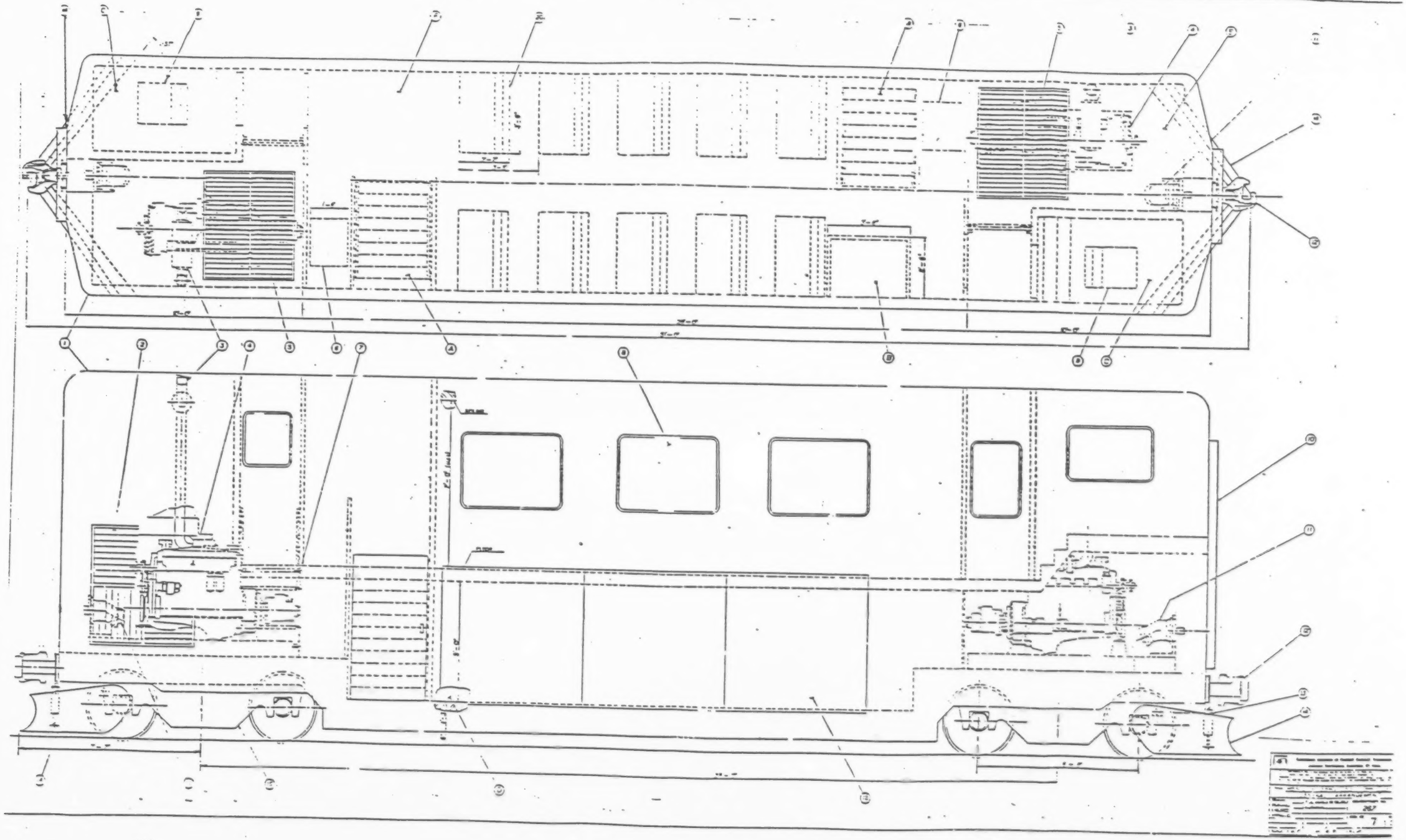
TYPE II (c/w HYDROSTATIC TRACTION MOTOR)

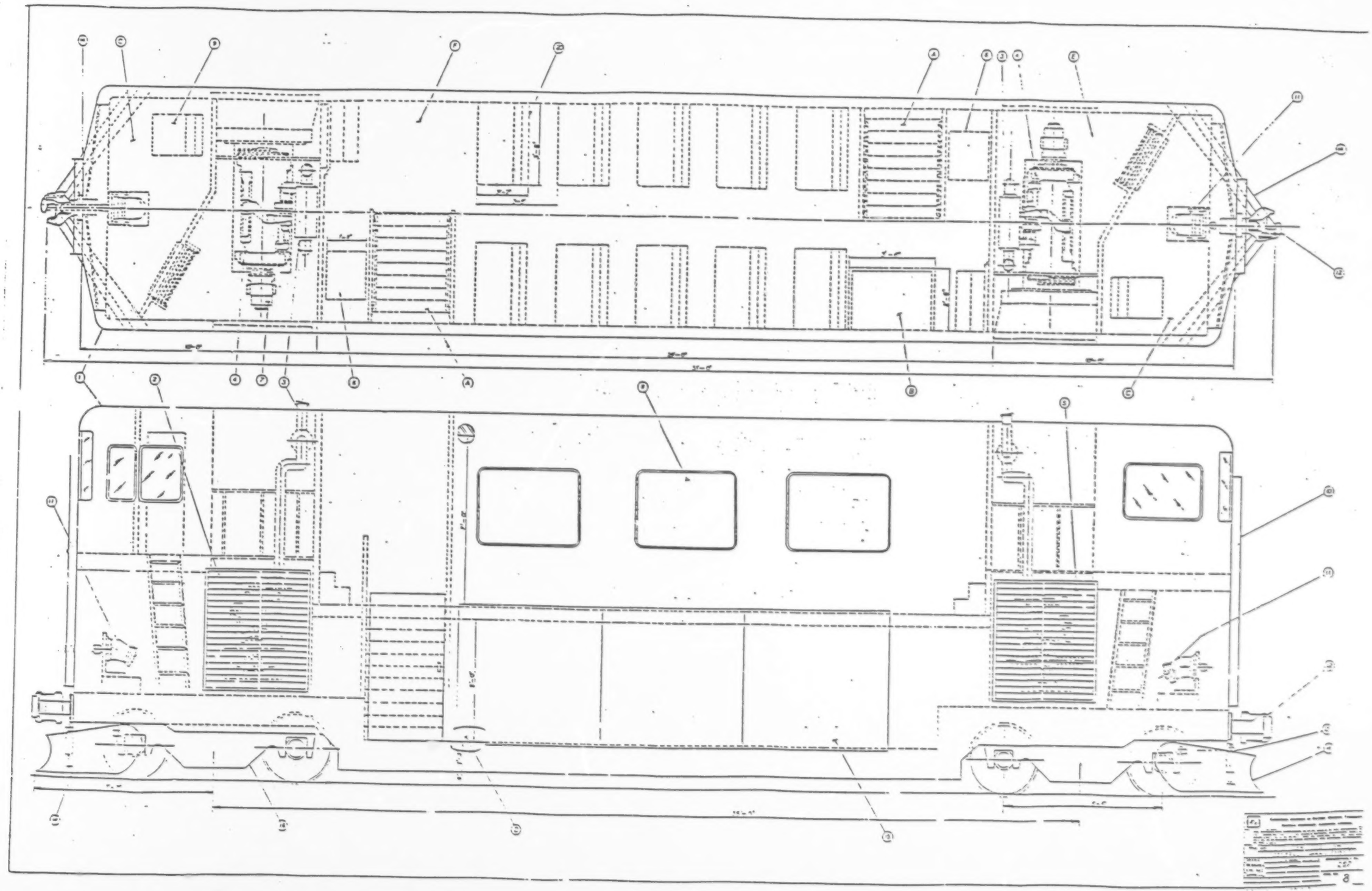


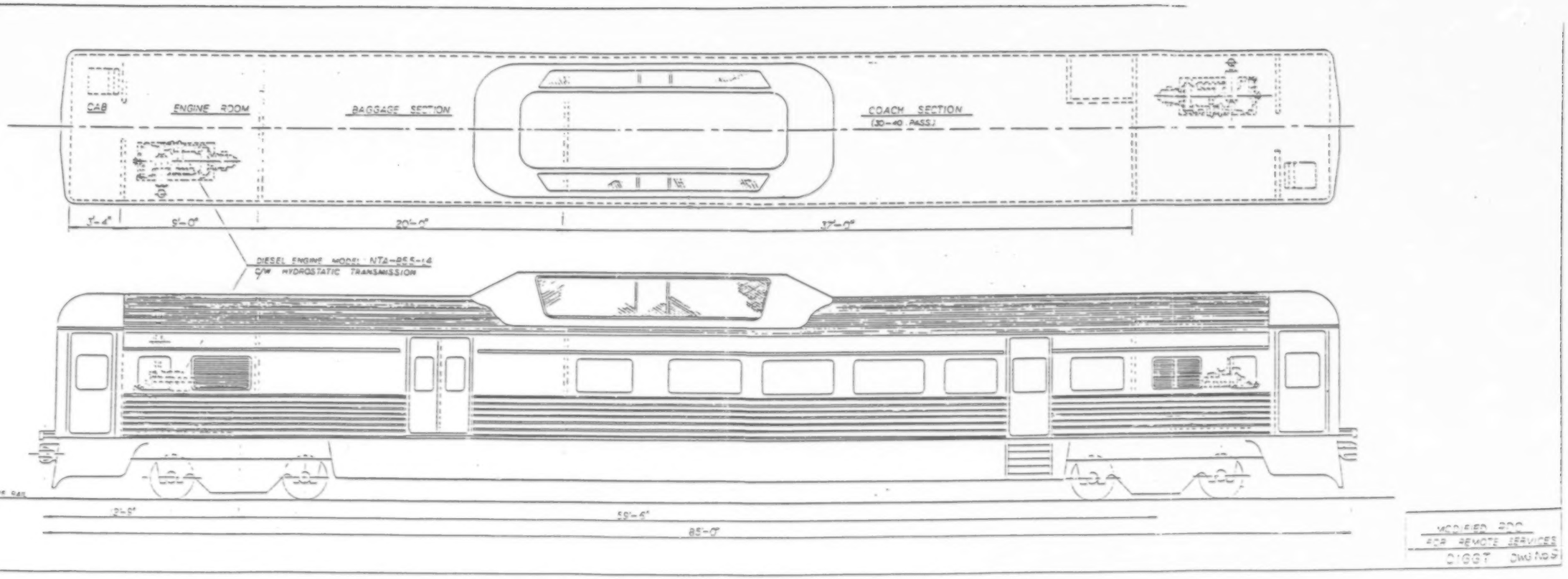
TYPE III (c/w HYDROSTATIC TRACTION MOTOR)



SECTION A – A







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APPENDIX H

FIGURES

1. Geometry of movement of snow over curved plow blades
2. Geometry of movement of snow over a flat plow blade
3. Apparent incline of plow surface presented to snow sheet
4. Basic version tractive power requirement
5. Juggernaut tractive power requirement

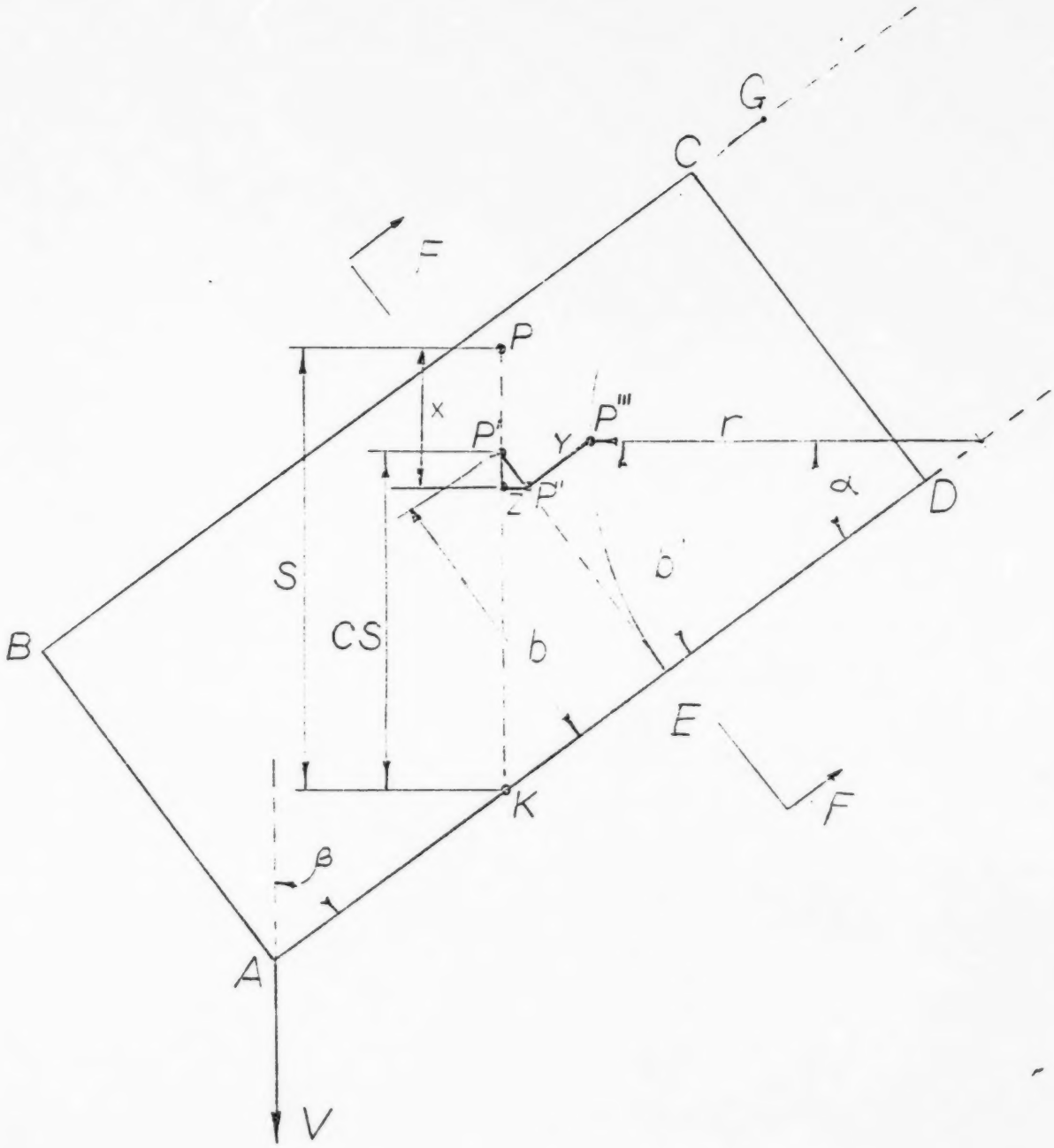


Figure 1 Geometry of movement of snow over curved plow blades

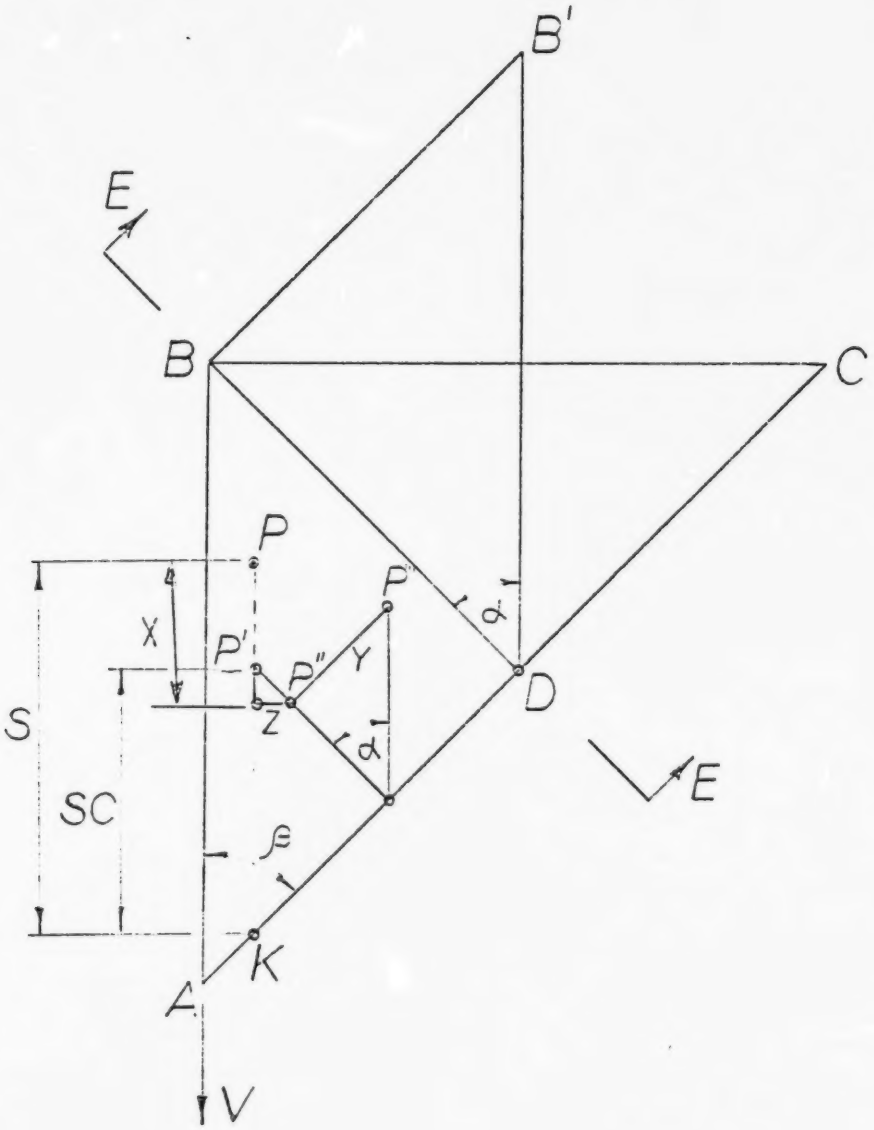
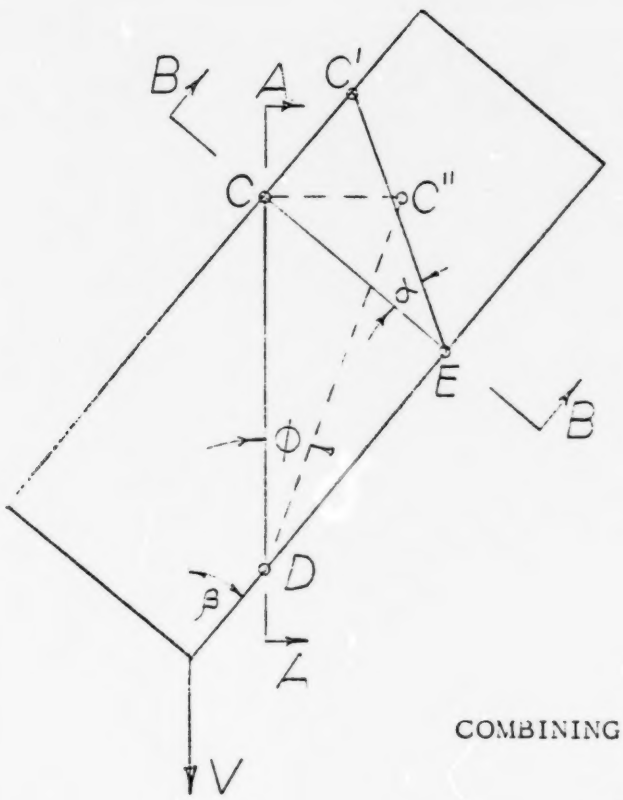


Figure 2 Geometry of movement of snow over a flat plow blade



Δ ECC' $\equiv$ SECTION ON 'BB'

Δ DCC'' $\equiv$ SECTION ON 'AA'

TAN α = $\overline{CC'}/\overline{CE}$ (1)

TAN ϕ = $\overline{CC''}/\overline{CD}$ (2)

SIN β = $\overline{CE}/\overline{CD}$ (3)

CC' = CC'' (4)

COMBINING (1), (2), (3) AND (4):

$$\text{TAN } \alpha = \frac{\text{TAN } \phi}{\text{SIN } \beta}$$

Therefore, α = TAN^{-1} (TAN ϕ/SIN β)

Therefore, if β = 20, ϕ = 30

Then α = TAN^{-1}(TAN 30/SIN 20)

Therefore, $\alpha \approx 60°$

Figure 3 Apparent incline of plow surface presented to snow sheet

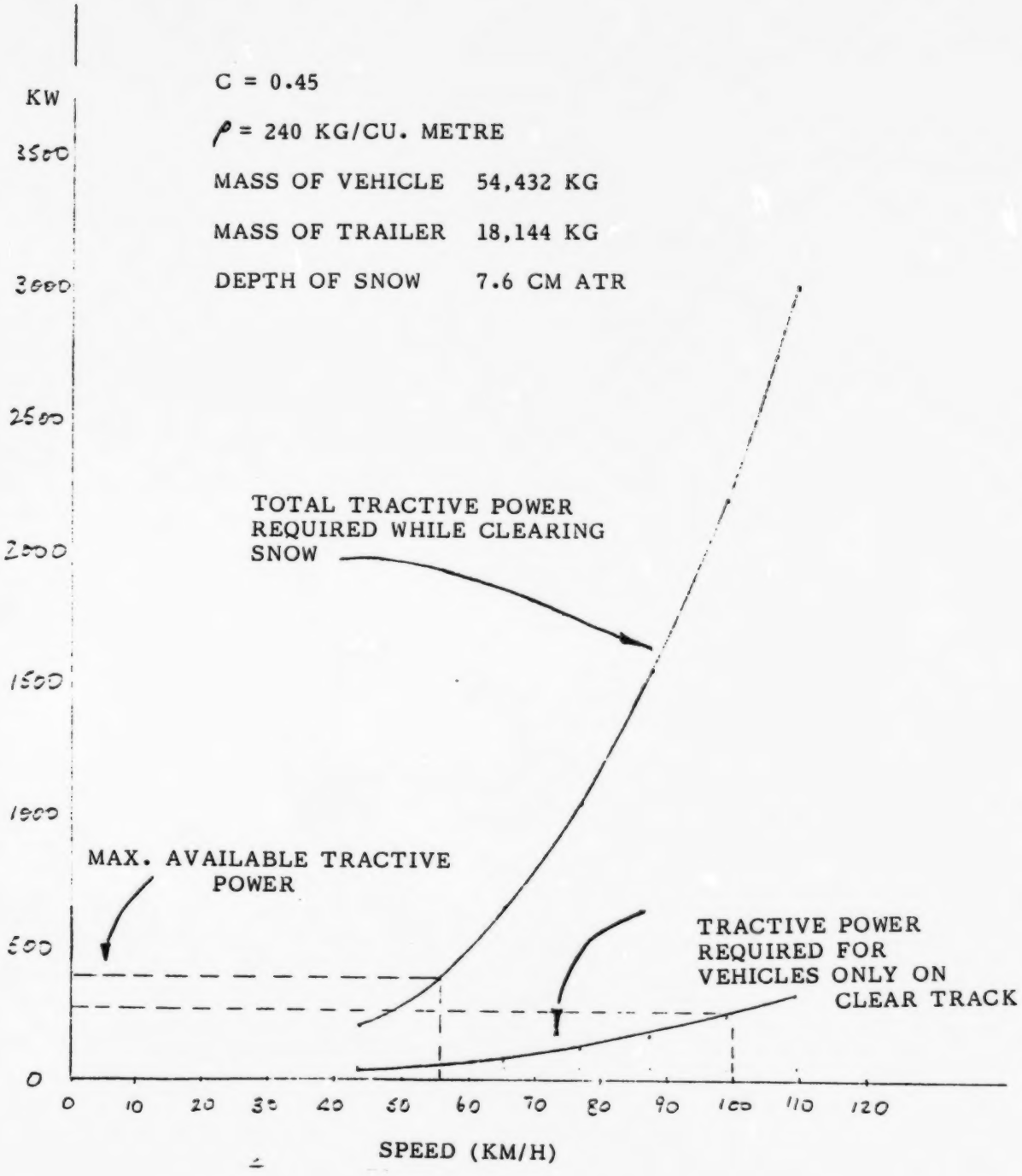


Figure 4 Basic version tractive power requirement

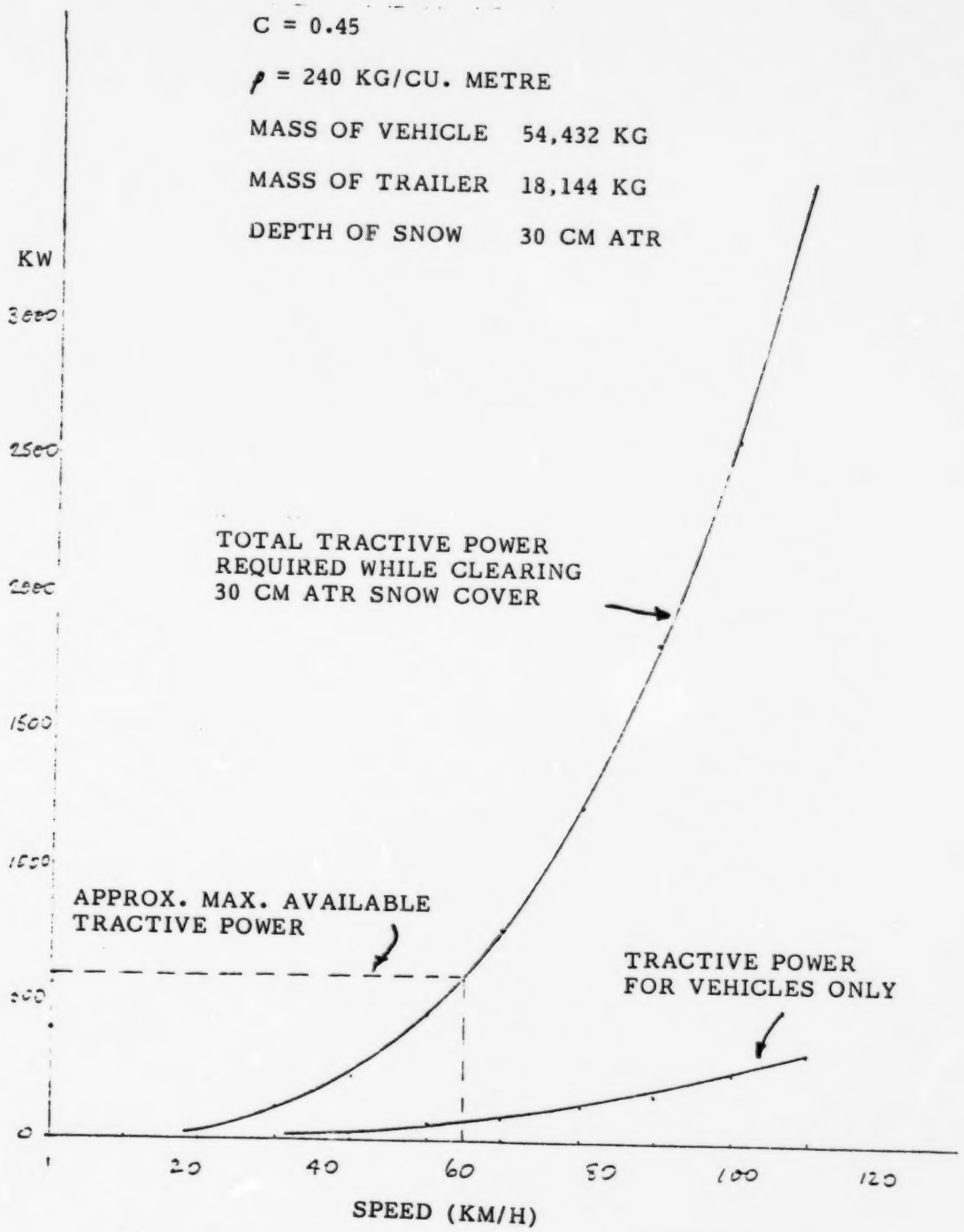


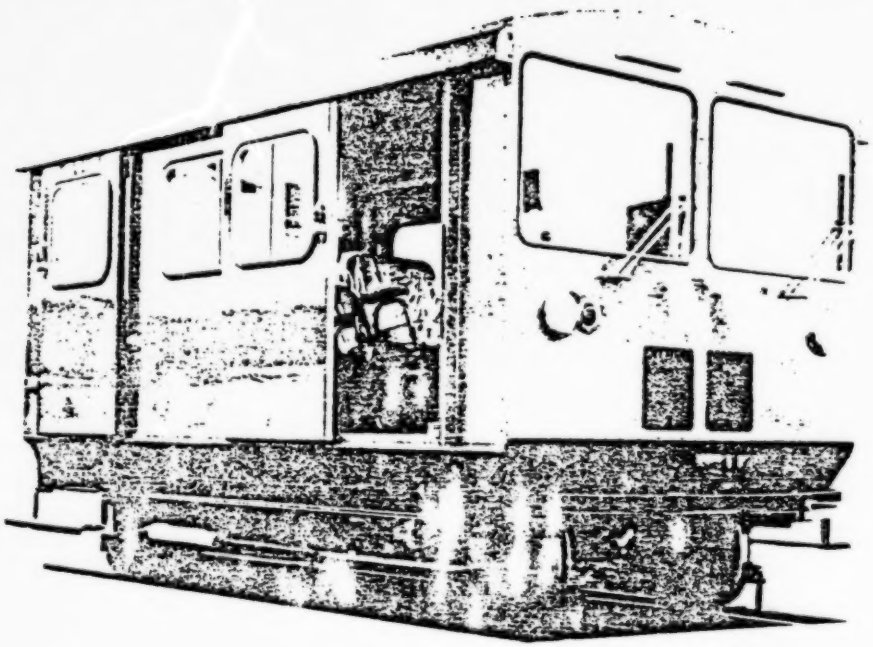
Figure 5 Juggernaut tractive power requirement

APPENDIX I

WICKHAM RAIL CAR

WICKHAM

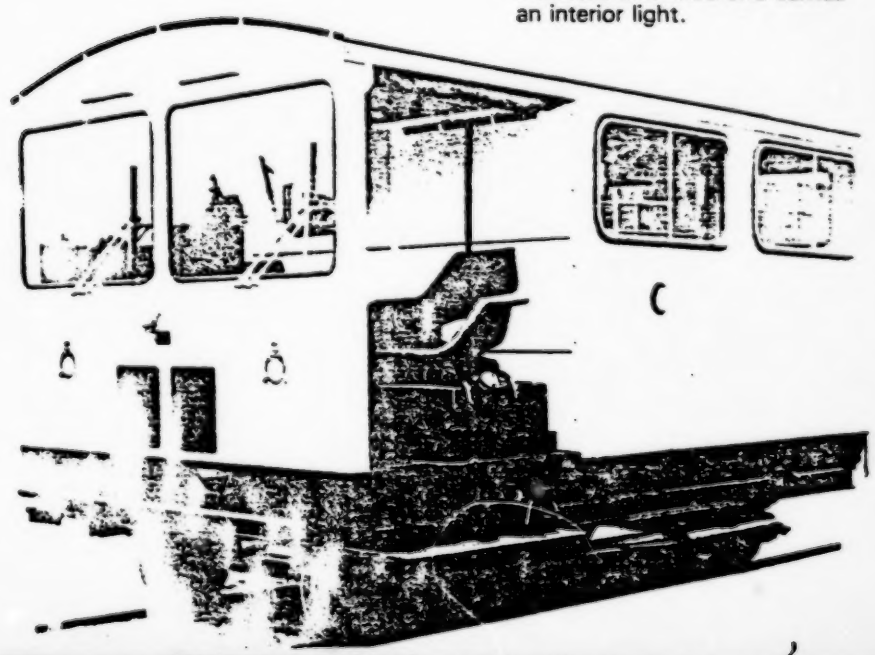
Type 38 inspection car and variants



The Type 38 is a result of many years of development to achieve a thoroughly practical, moderately priced all purpose engineer's car which can also provide rapid transport for senior officials. Its long wheelbase and method of suspension give it excellent riding characteristics which, with the well upholstered reversible seating, ensures comfortable travel.

The standard Type 38 is powered by a four cylinder, water cooled diesel engine, although a petrol engine can be fitted if required. Normal transmission from the four speed gearbox is by cardan shaft to a reversing box on the drive axle. If two axle drive is required the reversing box is chassis mounted with a chain drive to both axles.

The standard inspection car has driving positions at both ends, but the car can be supplied with one driving position only if so desired. Where special circumstances require it, a built in turntable can be fitted. The robust steel chassis is suitable for mounting cow catchers or special collision bars and is designed to haul a trailer. The all steel body has two sliding doors on each side and opening windows. The roof is insulated and lined and carries an interior light.



A number of special options are available, such as roof mounted warning lights and spot lights. Also solar control glass can be fitted, or heaters, according to operating conditions.

The Type 38 inspection car chassis with one driving position is ideal for the fitting of other forms of special body, such as the ambulance car illustrated, which has double doors at the rear giving clear access for stretchers.

TELEPHONES:
WARE 2491 (7 LINES)
TELEX: 81340
TELEGRAMS & CABLES:
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SPECIALISTS IN THE DESIGN AND CONSTRUCTION OF PASSENGER INSPECTION AND MAINTENANCE RAILCARS

NON-FERROUS AND FERROUS FOUNDERS

ESTABLISHED 1886

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LIEBERS, BENTLEYS
MARCONI

REGISTRATION: ENGLAND 126801

D. WICKHAM AND COMPANY LIMITED

REGISTERED OFFICE

CRANE MEAD, WARE, HERTFORDSHIRE, SG12 9QA, ENGLAND.

OUR REF SPEC/38/INS/680

YOUR REF.

DATE April 1984

S P E C I F I C A T I O N

WICKHAM TYPE 38 DIESEL DRIVEN INSPECTION CAR

1. GENERAL

This inspection car is designed to carry up to 8 persons and haul a trailer loaded with equipment and tools. It is an enclosed car and is fitted with a driving position at both ends.

Available for all rail gauges from 1000 mm to 1676 mm.

2. PERFORMANCE

2.1 Minimum speed laden on the level - 86 km/h.

2.2 Maximum speed laden on a 3% grade - 62 km/h.

2.3 Maximum payload - 1000 kgs.

2.4 Maximum trailing load - 7200 kgs.

2.5 Maximum speed laden with a 7200 kg trailing load on the level - 82 km/h

2.6 Maximum speed laden with a 7200 kg trailing load on 2% grade - 45 km/h

2.7 Seating for 8 persons including the driver.

2.8 Range up to 560 kms at 40 km/h and 430 kms at 56 km/h (inspection car only)

NOTE: All speeds are based at sea level and average ambient temperatures with a final drive ratio of 3.27 to 1 and maximum engine speed of 2800 r.p.m.

3. DESIGN DETAILS

3.1 Engine

The car is powered by a Perkins 4.236 water cooled diesel engine. Details of the engine are given in the maker's leaflet which is attached. Cooling is by forward mounted radiator with engine driven fan giving ample cooling when running in either direction.

3.2 Transmission

Power from the engine is transmitted through a single dry plate clutch and four speed automative type gearbox and then by cardan shaft to a fully enclosed, forward-reverse direction box mounted on the drive axle, giving four speeds in both directions.

3.3 Fuel Tanks

Fuel tanks are fitted with a total capacity of approximately 50 litres. These are filled from outside the car and a lockable filling cap is fitted.

3.4 Chassis Frame

The chassis frame is fabricated from rolled steel channels and sections electrically welded.

3.5 Drawgear

The car is designed to haul a trailer and draw bar brackets are fitted front and rear.

3.6 Running steps are fitted on each side for access to the car.

3.7 Bumpers

Spring type bumpers are fitted at each end.

4. RUNNING GEAR

4.1 Wheels

550 mm tread diameter cast steel wheels are hydraulically pressed on to the axle journals.

4.2 Axles and Axle Boxes

The axles are made from high grade alloy steel machined all over.

The axle boxes are made from cast steel with two taper roller bearings per box.

4.3 Suspension

Suspension is by semi-elliptic leaf springs and bushed radius bars locating the axle boxes to the chassis frame.

4.4 Brakes

Brakes consist of cast iron shoes operating on all four wheels. These are operated by compressed air and controlled by a foot pedal at the driving position. Air pressure is provided by an engine driven compressor. A hand lever to operate the brakes for parking is provided at the driving position.

5. SUPERSTRUCTURE

5.1 The body is fully enclosed. It is constructed of sheet steel, with end screens at both front and rear and two full length side panels fitting with sliding doors.

5.2 Windscreens

End screens are fitted with two full view fixed type safety glass windscreens providing excellent vision in both directions.

5.3 Roof

The roof is of steel construction and is insulated. A mechanical ventilator is fitted in the roof.

5.4 Side Panels

The side panels are constructed of sheet steel and are fitted with safety glass windows on each side of the vehicle. These windows are half opening type sliding in the horizontal plane.

5.5 Doors

Two sliding doors are fitted at each side. Each door is fitted with a safety glass window, handle and lock. Doors are adequately sealed against rain. The windows are half opening type sliding in the horizontal plane.

5.6 Floor

The floor is of wood construction covered in high grade linoleum.

5.7 Seating

Seating consists of six or eight comfortable fully reversible individual seats upholstered in sponge rubber and covered in top quality P.V.C.

6. CONTROLS

The car has a driving position at both ends.

6.1 Driver's controls are conveniently grouped and consist of:-

6.1.1 Foot operated throttle
6.1.2 Foot operated clutch
6.1.3 Foot operated air brake
6.1.4 Hand operated gear selection lever
6.1.5 Hand operated reversing valve
6.1.6 Hand operated parking brake

One set of pedals and levers are provided which are transferable from one driving position to the other.

6.2 Driver's Instrument Panels

The driving positions are provided with the following instruments:-

6.2.1 Key switch incorporating a cold start position and warning light
6.2.2 Engine stop control
6.2.3 Combined switch for head and tail lights
6.2.4 Air pressure gauge
6.2.5 Low air pressure warning bell
6.2.6 Oil warning light
6.2.7 Water temperature gauge
6.2.8 Horn switch
6.2.9 Speedometer
6.2.10 Battery charge indicator
6.2.11 Interior light switch
6.2.12 Fuse box

NOTE: One driving position is provided with a fuel gauge on the instrument panel and a distance recorder is fitted to the speedometer at the other end.

6.3 Electrics

The electrical system operates on 12 volts. It comprises an engine driven alternator with integral voltage regulator, engine starter and heavy duty battery for starting and lighting.

6.4 Lighting

Lighting consists of two white headlights and one red tail light at each end which are arranged to be switched in the direction of travel. An interior light is also fitted.

6.5 Audible Warning

A powerful electric horn is fitted at both ends.

6.6 Windscreen Wipers

Electrically driven windscreen wipers are fitted in front of the windscreens at both ends.

7. OTHER ITEMS

7.1 Tool Kit

A kit of tools is provided.

7.2 Operating and Maintenance Instructions

Each vehicle is supplied with a set of operating and maintenance instructions. These contain:-

7.2.1 Spare parts list detailing parts used in the construction and giving part numbers, code numbers and descriptions.

7.2.2 Maintenance instructions and engine handbook.

7.2.3 Handbook of driving instructions.

7.2.4 Instructions applicable to any special equipment fitted or supplied with the vehicle.

7.2.5 Prints on paper of the general arrangements covering chassis, direction box, braking system, electrical system and controls for maintenance and replacement parts ordering.

8. OPTIONAL EXTRAS (AT EXTRA COST)

8.1 A hand operated spotlight mounted at each end.

8.2 Rail Sweeps

Rubber bladed rail sweeps which are secured to the axle boxes at each end of the vehicle. They are adjustable for height to allow for wear.

8.3 Solar control safety glass fitted on all windows.

8.4 Orange flashing beacon fitted on vehicle roof.

8.5 Cabin heater.

8.6 Cow-catchers at both ends.

9. PAINTING

The cars are finish painted before shipment. This is to a very high standard and all surfaces are cleaned and thoroughly prepared before painting and given a prime coat and two finishing coats. Paints used are to British Standard Specification for the duties envisaged.

The colour scheme is as follows:-

Chassis frame and running gear	- Black
Superstructure	- Yellow, Red or Green according to choice, with Yellow and Black chevron panels at front and rear.
Roof	- Silver

NOTE: It is possible for the superstructure to be painted to a Railway's own colour requirements if these are provided at the time of ordering.

10. INSPECTION

All units despatched from our Works are tested and inspected by our own staff prior to packing for shipment. If outside inspection is involved, this is to be carried out at our Works prior to packing and despatch. Full facilities will be offered to Inspectors for carrying out their work.

11. SHIPPING DETAILS

The cars are normally shipped unboxed, but protectively packed on their own wheels. All external fittings which are likely to be damaged in transit are removed and stowed inside the vehicle prior to shipment. Any spares ordered at the same time as the cars would be shipped with the cars or in separate cases, according to circumstances.

Approximate dimensions for shipping are:

Cube	21.31 m^3
Length	388 cms
Width	230 cms
Height	238 cms
Gross Weight	2550 kgs

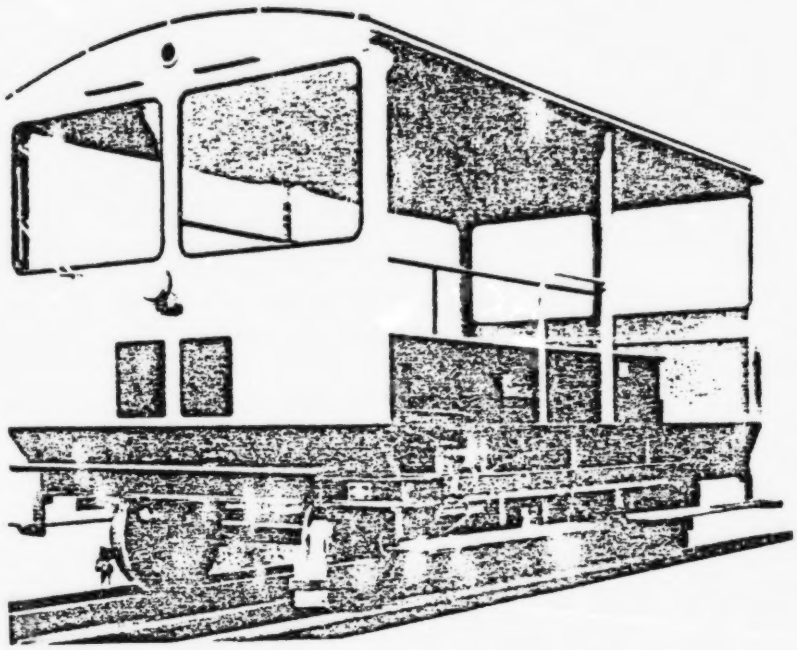
WICKHAM

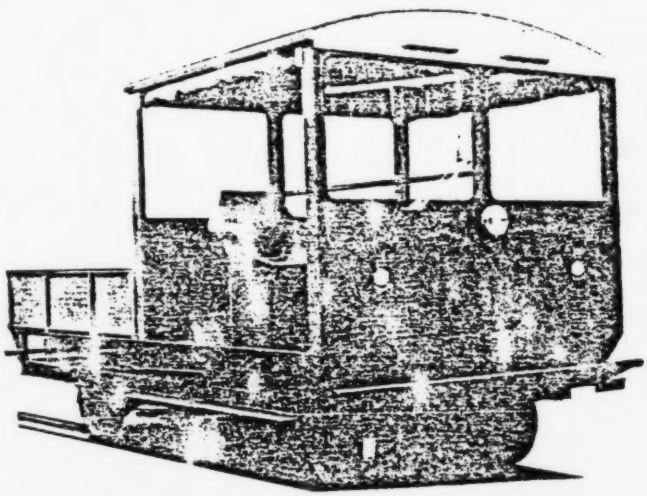
Type 38 gang car and variants

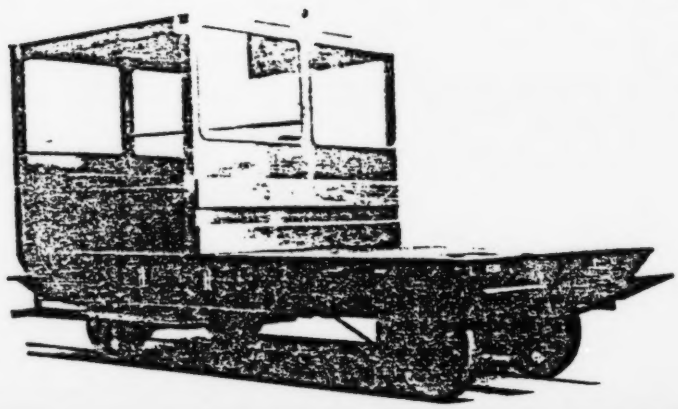
The Wickham Type 38 is the result of many years of development to produce a thoroughly practical, moderately priced all purpose engineer's vehicle with a good working performance. The gang car is available with either a fully enclosed body that has two sliding doors on each side, or semi-enclosed with protective side curtains. Both versions can have a single driving position or controls at each end. Driving positions have a bucket type seat, and a longitudinal bench seat has space for a further fourteen persons. The bodies are of steel construction with safety glass windscreens giving a clear and uninterrupted view of the track. In the enclosed body all side windows are of the opening type.

The standard Type 38 is powered by a four cylinder water cooled diesel engine, but a petrol engine can be fitted if preferred. Standard transmission from the four speed gearbox is by cardan shaft to a reversing box on the drive axle. If two axle drive is required the reversing box is chassis mounted with chain drive to both axles.

The robust steel chassis is designed to mount cow catchers or collision bars and to haul trailing loads. A built-in turntable is available as an option. The suspension incorporates the Wickham radius arm which, with the long wheel base, gives the car excellent riding characteristics.







The Type 38 gang car chassis with a single driving position is suitable for mounting other body variations, such as the open lorry type with drop sides or the flat metal deck transporter, both illustrated. These have the same type of short cab with seating for the driver and crew, providing a basic vehicle which can be adapted to serve many purposes.

Type 38 Performance

The figures for maximum speed of the Type 38 trolley are based on the following:-

Engine:- Perkins 4.236 rated at 80 B.H.P. @ 2800 rev/min (S.A.E. J.270)
Gearbox:- Ford 2801E 4 speed Ratios 6.482:1, 3.092:1, 1.686:1 and F:1

The engine performance figures are based on the following losses due to auxiliaries and transmission efficiency are 0.847 x the bare engine power, and there are no losses due to altitude temperature and humidity.

The weight of the trolley is 2590 kg tare and 3590 kg laden and the weight of the trailer 4000 kg.

Wheel diameter 0.55 m.

FINAL DRIVE RATIO	SPEED K.P.H.			
	CAR LADEN LEVEL TRACK	CAR LADEN + TRAILER LEVEL TRACK	CAR LADEN 2½% GRADE	CAR LADEN + TRAILER 2½% GRADE
3.27:1	86	86	81	51
3.511:1	82	82	79	49
4 : 1	72	72	71	46
4.5 : 1	64	64	64	44

STANDARD FOR PERKINS

2500 R.P.M. RATIO	SPEED K.P.H.			
	CAR LADEN LEVEL TRACK	CAR LADEN + TRAILER ON LEVEL TRACK	CAR LADEN 2½% GRADE	CAR + TRAILER ON 2½% GRADE
3.27 - 1	76	76	72	45
3.511 - 1	73	73	70	43
4 - 1	64	64	63	41
4.5 - 1	56	56	56	39

APPENDIX J

CONCEPTUAL DESIGN OF REMOTE SERVICES RAIL PASSENGER VEHICLE FUNCTIONAL PERFORMANCE REQUIREMENTS

J.1 INTRODUCTION

The design of the vehicle will be such that it will provide safe, efficient and economical passenger rail transportation between small communities in remote areas with very low traffic density.

J.2 GENERAL ARRANGEMENT

This will have the following features:

(1) Seating capacity: 20 persons minimum.

(2) Capacity in a separate trailer for 500 cubic feet of baggage, including accommodation for flammables such as gasoline and propane. Freight zone to be 20 feet long minimum.

(3) Adequate access to permit the loading/unloading of snow machines, canoes, wood stoves, 45 gallon oil drums, etc. To facilitate this, the height ATR of freight zone floor to be kept as low as possible.

(4) Unisex washroom fitted with chemical toilet, wash basin and holding tank.

(5) Single control cab, vehicle to be wye-d at terminals.

(6) Single entry door on one side acceptable.

(7) Sanders and sandbox may be required.

(8) Forced ventilation system optional.

(9) Primary heating system with auxiliary back-up.

(10) Head lights, ditch lights, classification lights and strobe lights.

(11) Lifting eyes and jacking pads for re-railing.

(12) Horns and bells to railway standards.

J.3 PERFORMANCE REQUIREMENTS

(1) Top speed 100 km/h.

(2) Brakes to be capable of stopping vehicle in the distances specified as follows:

50 mph 1600 feet

(3) Vehicle to be capable of operating in conditions of 3 inches ATR depth of snow covering at reduced speed and negotiating furrows of highly compacted snow caused by road plows at level crossings.

(4) Operating temperature range: -50°F (-45.6°C) to +100°F (37.8°C).

(5) Range 500 km.

(6) Buff load eliminated.

(7) Heating system capable of maintaining passenger accommodation at 50°F (10°C) with engine stopped while outside ambient temperature is -40°C for minimum period of six hours.

(8) to be capable of handling stretchers in heated area and to store stretchers.

J.4 PHYSICAL ARRANGEMENT

(1) Vehicle to conform to the mechanical clearances specified in CN Spec H.D. 37, sheet 6-1 (ref. fig. 1).

(2) Vehicle must be able to negotiate a 1,000 ft (305 m) radius vertical curve and a 251 ft radius (76.5 m) horizontal curve.

(3) Axle loadings not to exceed 25 tons (222 kN).

(4) Vehicle to be equipped with a coupler at each end. Coupler centreline to be 34½ inches (0.88 m) ATR.

(5) Maximum size permissible between truck centres and outside truck centres must fall within the equipment restriction illustrated in Figure 2.

(6) To run on standard gauge 4 feet 8½ inches.

(7) Car body to rail clearance to be a minimum of 4½ inches; trucks to car body to be minimum of 2½ inches, under worst loading conditions.

J.5 GENERAL

In general, the design of vehicle should follow with the Manual of Standards and Recommended Practices of the Mechanical Division of the AAR for passenger vehicles.